MERSEYSIDE

Ancient Corporate Seal of Liverpool.
(Destroyed 14 Oct., 1743.)

Seal in use.
(Copy of above, and full of errors.)

MERSEYSIDE

A HANDBOOK to Liverpool and District prepared on the occasion of the Meeting of the British Association for the Advancement of Science in Liverpool, September, 1923

EDITED BY
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FOREWORD.

In the preparation of this handbook an attempt has been made to present a survey of Merseyside in its various aspects, Municipal, Industrial and Scientific, rather than to dwell on Liverpool and its immediate environs.

When the British Association last met here (in 1896) the editor of the Handbook prepared on that occasion had a like object in mind, but during the quarter of a century that has passed since then much has occurred which has necessitated a wider outlook and a somewhat different treatment of the subject.

It is manifestly impossible in a small volume such as this to present articles on all aspects of municipal and commercial history and activity, nor to take cognizance of all the industries of the district or the details of its natural history, but it is hoped the range of articles is comprehensive enough to give the visitor a picture of the locality in which he is staying and to point out the salient features of interest to those concerned more purely in Science. This must be the excuse for the omissions which some readers may feel.

The articles have in every case been written by authors highly qualified to deal with their particular subjects, and the Local Committee would wish to take this opportunity of thanking them for the trouble they have taken in their preparation. They wish to thank also the many chemical firms of the district who have so kindly provided data from which the article on these industries is built up. Such co-operation has been of the greatest value.

The British Association seeks to promote interest in Science and its applications. In few parts of the country has Science been of greater value than on Merseyside, and so it is hoped that this volume by presenting a general survey of the district in the broadest sense will help to promote the work of the British Association on whose account it has been prepared.

ALFRED HOLT.

Liverpool, August, 1923.

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THE LIVERPOOL AND DISTRICT REGIONAL SURVEY.—POPULATION MAPS, &c.

W. Hewitt, B.Sc., Assoc. R.S.M.

Hon. Director, The Liverpool and District Regional Survey Association.

"Regional Survey, in its widest significance, is to a large extent preparatory to Regional Planning, and its primary object is to collect and co-ordinate all data bearing on the past development, present conditions, and future possibilities of the areas under consideration. For this purpose it tries to organise different groups of workers, each engaged in some particular local survey, to keep them in touch with one another, and to co-ordinate the results obtained so as to get ultimately a view of a neighbourhood as a whole made up of related parts. The results of the different surveys are primarily expressed in the form of carefully prepared distribution maps, and the task of studying the significance and relationship of these maps —for example, geological, botanical, soil maps, etc., on the one hand, and agricultural, industrial, and sociological maps on the other—is a central feature of the work. It needs the help of workers of many kinds, and one very valuable educational result of it is that it brings so many different classes of workers together and gives them a common field of interest. That is a great gain in these days of intense specialisation.

"In the coming days there is likely to be a very considerable redistribution of industry and population; new factors in the localisation of different forms of manufacture are beginning to operate; there are new modes of communication, and there will be different relationships between the old ones. Fresh value is being attached to the soil, and suitable and well-placed

land for allotments will be a big factor in the expansion of cities. That of itself indicates a new relationship of the towns and urban areas to one another and to adjacent rural districts. The bridging or tunnelling of the Dee estuary, for example, the deepening and control of the main channel of the river, the reclamation of much of its tidal area, and the rapid industrial development of the mineral hills of its Welsh flank may vitally alter the value of the space relations of the Wirral Peninsula. If so, will it be valued as in the main a rural and agricultural region separating two "conurbations" (Merseyside and the Flintshire coast)? Or will this intermediate position lead, through the old policy of *laissez faire*, to its rapid industrialisation."

The preceding paragraphs, taken from the preliminary prospectus of the Liverpool and District Regional Survey Association, issued in 1918 by Professor P. M. Roxby, indicate the aim and scope of the work which such an Association might undertake. The area which it was proposed to study comprised those portions of Lancashire and Cheshire focussing upon the Mersey estuary, or to a lesser extent upon the estuary of the Dee, roughly contained in a radius of from 15 to 20 miles from Liverpool. It extends approximately to Southport, Wigan, and Warrington in Lancashire, to the Delamere Forest district and Chester in Cheshire, and includes the north-east slopes of the Flintshire hill range on the other side of the estuary of the Dee. The Wirral Peninsula, an isolated unit area which is at present in an interesting stage of development, has, in the first instance, received special attention.

The urgent importance of such surveys—which must ultimately be carried out by public bodies with larger resources and facilities than are possible in the case of an association of voluntary workers—needs no argument, having in view the various projects for the co-operation of Local Authorities in the development of their conjoint areas, which are now being discussed or actually in process of organisation. The recent constitution of a joint body of representatives of the

Merseyside boroughs—Liverpool, Bootle, Birkenhead and Wallasey—to consider schemes of co-operation in various activities connected with the densely populated areas clustered round the lower portion of the Mersey estuary; the formation last year, under the auspices of the Ministry of Health, of a Joint Town Planning Committee for the Wirral area; and the probability that a scheme for the regional planning of south-west Lancashire (under a joint body representative of the local authorities in that region) will be called for at no distant date, all point to the necessity for the systematic study of the districts concerned, and the accumulation of accurate data upon which satisfactory planning schemes may be based.

One of the first pieces of work carried out by the Association was the preparation and discussion of a series of maps, showing the *relative density of the population* in the townships* comprised in the area, for each decennial period from 1801 to 1921, based upon the census returns. These maps are now in process of publication so as to be available for use by local authorities, or for study purposes in schools. (Examples, on a much reduced scale, of the maps for 1801 and 1911 accompany this article.) A very cursory examination of the maps discloses a number of interesting problems as to the conditions which have influenced the growth of centres of population, and suggests various lines of further enquiry and speculation as to the probable or desirable lines of future development.

The *map based on the census for* 1801, for example, shows a marked concentration of the population at very few points:—Liverpool, Wigan, Warrington, Northwich and Chester. Most of these are in continuation of ancient settlements at important nodal points on the lines of the ancient roads, viz: *Warrington* at the

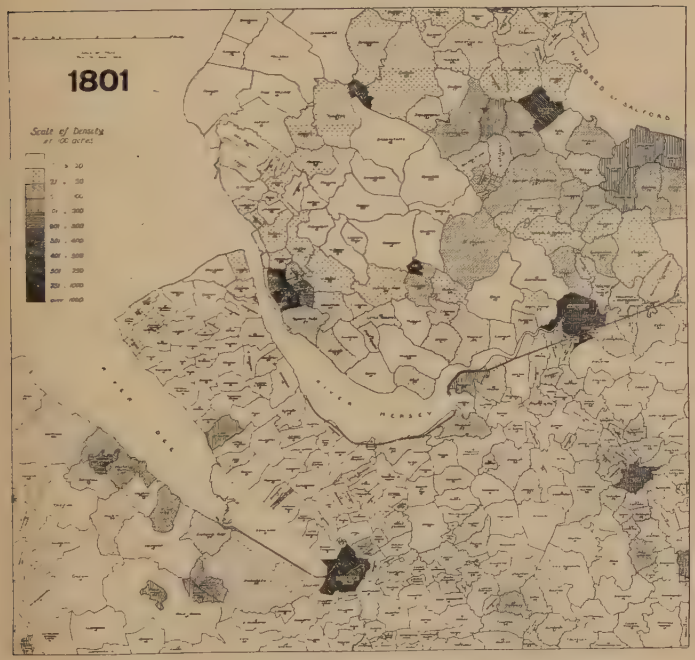
*The township is taken as the unit area for calculating the density, because the census returns are published on that basis. It is important to keep this fact in mind when studying the maps.

point where an important Roman road to the north forded the river Mersey, where also the bridge formed a point of strategic importance throughout the middle ages: and where, until the middle of the 19th century, the roadway and railway connections between Liverpool and the Midlands and London found their first possible crossing; *Wigan*, on the Roman road running north from Warrington to Lancaster and Carlisle (and already at the beginning of the 19th century supplying a considerable amount of coal from its mines to Liverpool and other districts); *Chester*, the north-western terminus of the Watling Street, the border military station at the junction of North Wales and England (of vital importance from Roman times onwards), and a port which, before the silting up of the estuary, carried on a considerable trade with Ireland; and *Northwich* on the Weaver, with its ancient saltworks. *Liverpool*, favourably situated on the lower part of the Mersey estuary, had gradually during the 18th century built up an important shipping trade, especially with America, and served as the outlet for the growing manufactures of northern England, as well as the gateway for raw materials required for those industries.

At the other end of the scale we note some areas with very sparse population; such as those adjoining the Lancashire coast, where the belt of sand dunes near the shore and the extensive peat mosses and marshy districts inland of the dunes offered little encouragement for settlements; a similar area of mosses and marshes lying between Ormskirk and St. Helens; the Delamere Forest upland area; the marshy fenland between Ince and Frodsham on the southern bank of the upper Mersey estuary, extending inland towards Chester up the valley of the Gowy; and the higher portions of the range of hills in Flintshire. As regards the Wirral Peninsula, the purely agricultural and undeveloped condition of the whole area is seen in the fact that the only district which shows an even moderate concentration of population is that of Neston, on the shores of the Dee estuary. Neston (with its

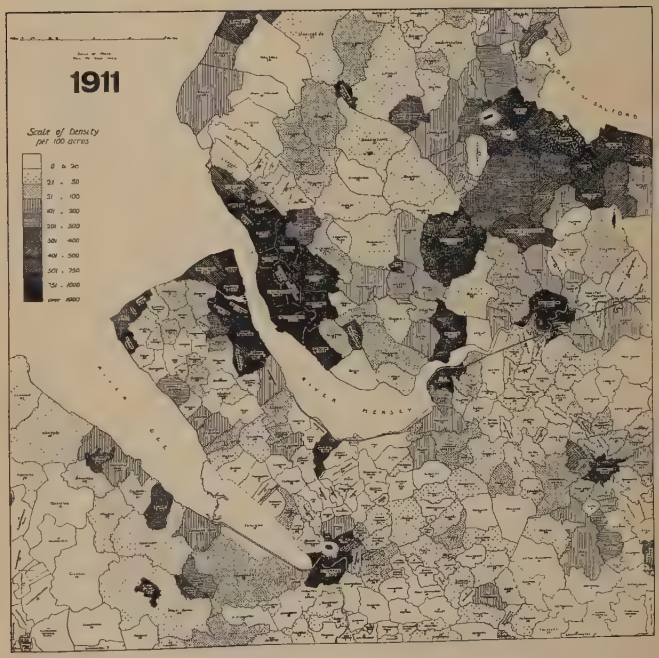
DENSITY OF POPULATION.

REGION OF MERSEY AND DEE ESTUARIES.



DENSITY OF POPULATION.

REGION OF MERSEY AND DEE ESTUARIES.



suburb of Parkgate) had been for some time the port for the Irish and other maritime trade in succession to Chester; it was also the administrative centre and market town for the peninsula, and a seaside resort. Birkenhead, Wallasey, and other now densely populated areas were at that period almost negligible either for population or activities.

The map based on the census of 1851 does not indicate a very marked change in the density and distribution of the population from that of 1801, except in the case of the Liverpool area, which had extended very considerably, and had influenced a considerable increase of population on the opposite side of the Mersey in Birkenhead (and to a smaller degree in the Wallasey district), where the large tidal inlet of Wallasey Pool, lying between Birkenhead and Wallasey, was also in process of development for dock purposes. Also the coal mining district of which Wigan is the centre was evidently growing rapidly; and especially Wigan itself, as the seat of important cotton and iron industries. St. Helens was coming into prominence in the midst of a coal mining district, and as the seat of a growing glass and chemical industry, which was also affecting the districts of Widnes and Runcorn.

An examination of the *map based on the census of* 1911 testifies to the very rapid growth and development of several extensive districts during the latter half of the 19th century, and to the spread of industrial conditions and the establishment of urban (or suburban) communities. Not only have the special centres of concentrated population referred to in the previous paragraphs extended their areas, but several other crowded and active centres have sprung into prominence under special favouring conditions. The very rapid development in the trade and commerce of Liverpool led to the extension of its dock and warehouse system both southward and northward along the shore of the estuary, and also to a considerable development on the other side of the estuary in the dock system formed out of the old Wallasey Pool. The

immense population concerned in the trade and commerce of Liverpool has spread itself out into the surrounding districts for residential purposes, and brought into existence large communities, which are to be found situated (*a*) on the dune land area adjoining the Lancashire coast as far northward as Formby and Southport; (*b*) eastward and north-eastward from the centre of Liverpool along the lines of railway, and (*c*) over the estuary, especially to the higher portions of Birkenhead and Wallasey, and the attractive seaside areas of New Brighton, Hoylake and West Kirby, besides a more sporadic distribution over a considerable part of Wirral.

A large district around Wigan situated on the coal-field has developed considerably, and has now extended so as practically to join up with St. Helens, thus forming a large and densely populated mining and industrial area. This area also approaches very nearly on the one hand to Widnes, which now stands out as a centre for the alkali and other chemical trades (fostered by the great facilities provided by the Weaver Navigation with the salt district around Northwich), and on the other hand to the busy manufacturing area centreing on Warrington.

The rapid growth of both Birkenhead and Wallasey is due not merely to their serving to house many of the workers in the commercial establishments of Liverpool, and to the docks and warehouses on the Wirral side of the Mersey estuary, but also to important industries established on both sides of Wallasey Pool (e.g., flour milling, seed crushing, cattle and meat trade, etc.), and to the very important iron shipbuilding and repairing works on the shore of the estuary. The extension southward from Birkenhead, on the borders of the estuary, of a densely populated area is primarily due to the establishment of important soap, candle and allied industries on the land adjacent to the small tidal inlet of Bromborough Pool, where the well-known works-village of Port Sunlight, established by Lever Bros., is also the centre of a rapidly expanding

residential district. (This southward extension of population and industry will be still more marked in the map based on the census of 1921, in consequence of the steady growth of new industrial establishments—oil mills, margarine works, oxygen manufacture, etc.—on the strip of land bordering the estuary almost as far as Eastham; and further considerable developments and extension will no doubt take place in the near future.) Still farther along the border of the estuary we come to Ellesmere Port, a well marked centre of population in the later maps, at the junction of the canal from Chester (and the Midland districts) with the Mersey, and now with the Manchester Ship Canal; a busy centre of industry with engineering, milling, chemical and other establishments. Still further south, past the marshes of Ince and Frodsham, we reach Runcorn with its industrial works and quarries, and Helsby with its important electric cable works, forming the nucleus of another rapidly filling area. The efforts which are being made to promote the establishment of industries on the land adjoining the Manchester Ship Canal—which runs close to the shore of the estuary from the entrance locks at Eastham to the mouth of the Weaver—will stimulate the gradual transformation of the whole coastal strip into an industrial area, bringing with it problems as to the localities for the housing of the necessary workers and the provision of new transport facilities.

The rise and influence of industry in the Deeside portion of Flintshire is also apparent in the growth of population at Connah's Quay, Flint, etc.; and the development of this coastal strip (together with the utilisation for the same purpose of a portion of the reclaimed land on the Wirral side of the artificial channel of the Dee) is already engaging the attention of the local authorities and others interested in the necessity for such development being on the lines of a well-planned scheme.

It will be seen from the map that the low lying and somewhat marshy belt behind the sand dunes on the

Lancashire coast still remains very sparsely populated, being given up to agriculture; as also the somewhat similar area running to the south-east in the valley of the River Alt. This tract, with its continuation in that of the agricultural land lying in the valley of the stream running south-eastward to the Mersey between the heights of Liverpool and those of Prescot and Huyton, forms a useful break between the two densely populated areas of south-west Lancashire (viz., the Liverpool district on the one side and the St. Helens and Wigan mining area on the other), and as such should receive constant attention in planning schemes for the region. The Delamere upland area, the higher portions of the Flintshire range, and the low fenland alongside the sluggish lower Gowy with its broadening extension into the Ince and Frodsham marshes adjoining the Mersey estuary, are all kept back by natural conditions from attracting any great settlement of population, though the marshland is being steadily reclaimed and made suitable for agriculture.

A careful study of the contours and natural drainage lines; the geological structure, and especially the nature of the surface deposits; the climatic conditions of the various localities as regards aspect, shelter from unfavourable winds and storms, local variations of rainfall, temperature, early frosts, etc., are all necessary to the successful planning of the most suitable development and utilisation of a region. Certain areas are naturally marked out by their situation, structure, and conditions as being suited to special purposes, while some are seen to be quite unsuitable as the sites of residential settlements. The greater part of the region with which the Liverpool and District Regional Survey Association is concerned is covered by a more or less thick deposit of boulder clay, out of which stand elevated patches of sandstone rock free from clay; while the surface in other parts shows accumlations of drift or blown sand. These clay-free areas formed the sites of many of the earlier settle-

ments (Ormskirk, Everton, Oxton, Ince, Chester, Capenhurst, etc.); and will naturally—other conditions as to locality, accessibility, aspect, etc., being satisfactory—be in favour for residential purposes. Some of these elevated areas, being unfitted for agriculture, have remained from early times in the state of open common land, covered with gorse and other heathland vegetation; and while a number have been enclosed and made use of for the larger and more expensive class of private residences, some (e.g., Bidston Hill and Thurstaston Common) have been secured as public open spaces, or are utilised for golf links, as are also the dune lands of Hoylake, Wallasey, Crosby, etc.

The area of the coalfield, from its importance as a national asset, will naturally be covered with shafts and mining settlements; and various industries dependent on an ample and cheap supply of fuel will locate themselves in close proximity. But it may be hoped that as schemes for the production of electricity on a large scale, at certain super-generating stations on or near the coalfields, are brought into operation, the surface industrial establishments may be spread over a much wider area and separated by open agricultural districts, thus providing more congenial conditions for the workers, with the abolition of the plague of smoke and soot which now constitutes so sore a trial in certain parts of the region.

Those districts adjoining the coast where the depth of water or the existence of natural tidal inlets offer the necessary facilities for docks and quays have naturally been taken for shipping; and in some cases important industries which depend upon the supply of raw materials from foreign sources have established themselves in the near vicinity; as in the case of the extensive flour mills, sugar refineries, seed crushing and oil industries, soap works, and tobacco works in the Merseyside district. The stream valleys, and the old mosslands, when properly drained, will be retained for agricultural purposes, and form the open spaces and

fresh air reservoirs separating the urban districts. To secure the best allocation of areas to their most desirable uses, to consider properly the inter-relations of the various specialised districts — commercial, industrial, agricultural, residential—requires full and careful consideration by regional representative bodies; and for the proper work of such bodies, a full and clear knowledge of the conditions, resources, and potentialities of the region, together with some knowledge of its past history, and the factors which have influenced its development along certain definite lines, are essential.

The Association, in addition to the work on the population maps, has initiated several other branches of investigation and prepared a certain number of maps and charts. An interesting series of maps of Wirral showing graphically the data contained in Domesday Book was drawn up for the Association by Mr. H. J. Peake; providing an excellent example of the methods and advantages of the presentation of data in the form of maps. An agricultural map of the Wirral area, showing the condition and use (pasture, arable, heath, etc.) of every separate parcel of land in 1918, was compiled from the observations of several workers, and this kind of map it is hoped to repeat at intervals. A detailed survey of the natural vegetation of the same area has been begun, with a view to elucidate the more primitive conditions and plant associations. The records for a number of years past have been obtained from the meteorological observing stations in both the Lancashire and Cheshire districts, and these have been analysed and are being tabulated in graphical form for the several factors; while a tentative rainfall map of the area has been drawn. Several maps of the region showing the physical features—elevation, stream courses and basins, surface geology, etc., have been prepared; as also a map showing the distribution and extent of the ancient mosses and meres in the Lancashire section, so far as records can be obtained. The results

of the detailed geological survey of the northern half of Wirral, on maps of the six-inch scale, have been obtained from the Geological Survey Office, and are being used as the basis of further detailed investigations of the economic geology, the character of the soils, etc. A commencement has also been made with the study and representation of the distribution of industries in the area, beginning with the Merseyside district.

THE PHYSIOGRAPHICAL FEATURES OF THE COUNTRY AROUND LIVERPOOL.

W. Hewitt, B.Sc., Assoc. R.S.M.

(*a*) *The Land Surface.*

The area at present considered is comprised within a radius of about 15 miles from the city, which carries it approximately to Southport, Wigan, Warrington and Chester, to the ridge of the coast range of Flintshire, and to the Point of Air at the outer limit of the estuary of the Dee.* It thus comprises the South-Western portion of Lancashire, the whole of that isolated portion of Cheshire forming the Wirral Peninsula, and a strip of North Wales forming the western margin of the estuary of the Dee, and includes also that estuary and the estuary of the Mersey, into which the natural drainage of the area is carried.

The Lancashire portion consists mainly of an extensive plain bordering the coast and rising gently to the eastward to the higher ground about Wigan, where the beacon hills of Ashurst and Billinge rise to 569 and 593 feet respectively. The late T. Mellard Reade described this plain as made up of two distinct physiographical areas, roughly divided by the 25 foot contour line, viz.: (a) a low lying area, in parts about four miles wide, covered by post-glacial beds of peat and marine silt, overlaid in parts by recent river alluvium or tidal mud and fringed near the shore with a belt of sand dunes, and (b) an undulating plain of boulder clay and

* This area is almost coincident with that shown on the convenient special map of "Liverpool and District," on the scale of 1 inch to the mile, published by the Ordnance Survey as Sheet 34. It is practically the area covered by the standard work on local geology, the *Geology of the Country around Liverpool*, 1891, by the late G. H. Morton. It is also the area selected for investigation by the recently established Liverpool and District Regional Survey Association.

drift sand, gently sloping up to rising ground on the east formed mainly by beds of the Carboniferous Series. This plain, especially in its higher portion, was until comparatively recent times, an area of meres, swamps and mosses which have now for the greater part been drained and brought under cultivation, but the memory of which persists in the numerous place names, Rainford Moss, Bickerstaffe Moss, Simonswood Moss, Kirkby Moss, Parr Moss, etc. (The well-known Martin Mere—which in 1692, shortly before drainage operations were commenced, is said to have covered 3,000 acres—lies just north of our area, but belongs to this system of lakes and mosses). The only streams of importance in this area are (1) the River Alt, a stream about 14 miles long, which runs in a north-westerly direction, through the valley separating the high ground of Liverpool from that of Knowsley and Prescot, to the neighbourhood of Formby, where it changes its course and at the present time continues in a south-westerly direction into the sea just south of Altcar and along a tidal channel parallel to the shore for almost two miles. (2) The Sankey Brook rising to the north of St. Helens, which with its tributary streams drains the eastern portion of our Lancashire area into the Mersey near Warrington.

The Wirral peninsula between the estuaries of the Mersey and the Dee consists, as to the main portion of its length, of a plateau area with a width of from six to eight miles at a general elevation of about 150 ft., with marginal ridges formed of the harder beds of the Triassic Sandstone rocks, rising on the west side at Heswall Hill to a maximum of 340 feet. The elevated ground, however, does not extend to the north shore of the peninsula, but stops somewhat abruptly, and gives place to a marginal low lying plain (with a width of between one and two miles below the 50 feet contour, and much of it below 25 ft.) of a somewhat swampy and marshy character, covered with peat and post-glacial silts, and fringed with a belt of sand dunes; in all respects similar to the low lying plain on the

margin of the Lancashire coast. This low lying strip is traversed from west to east for almost its full extent by the Birket Stream, which collects the waters of the streams running down from the northern portion of the adjoining upland area, and which formerly ran into the head of Wallasey Pool (before its enclosure for dock purposes) lying in the depression between the heights of Wallasey and Birkenhead. (A considerable tract of land round the head of Wallasey Pool lies below the level of the highest tides and is protected from flooding by the Wallasey (or Leasowe) Embankment—a stone structure on the north shore of the peninsula extending for a length of about 2½ miles, constructed in the early part of the nineteenth century). This low alluvial area also extends for some distance up the broad valley of the Fender stream, which running to the north-east from the higher slopes of the Heswall ridge traverses the peninsula diagonally and joins the Birket near Bidston village. In its southern and south-eastern portion the plateau area of the peninsula is broken by a wide belt of low lying fenland occupying the broad valley of the River Gowy (and of the smaller parallel streams of the Thornton Brook and Holpool Gutter), which river rises in the region south of Delamere Forest and runs northward into the Mersey a little to the east of Ellesmere Port. Beyond this low area, formerly overflowed by high tides and covered with post-glacial deposits and recent alluvium, the land rises sharply up the steep westerly scarps of the Frodsham and Helsby Hills (ridges of Triassic sandstone with an elevation of more than 400 feet), and the upland district of Delamere Forest. Besides the streams of the Wirral Peninsula already mentioned the only other important drainage system in that area is that of a number of streams from the central portion of the plateau joining together into a short trunk stream running into the Mersey through the tidal inlet known as Brombrough Pool.

The Flintshire portion of the area on the western margin of the Dee estuary—a strip of from two to three

miles in width, comprises the eastward slope of the coastal range which rises in the Halkin Mountain to a height of about 1,000 feet and falls rather steeply to the shore of the estuary.

(*b*) *The Coast Line.*

The seaboard of the area is washed by that part of the Irish Sea which is known as Liverpool Bay, and which is extended far inland (1) by the estuary of the Mersey—about 19 miles—in a line curving from about North to East as far as Runcorn Gap ; and (2) by the estuary of the Dee—which formerly ran, in a N.W. and S.E. direction, as far as Chester, a distance of about 19 miles. The estuary of the Dee is now occupied in its upper part for a distance of about seven miles from Chester by an area of land reclaimed from the sea, through which the tidal Dee flows in a straight and narrow artificial channel. Beyond Runcorn Gap —a rock bounded channel about 1,400 ft. wide—the (still tidal) valley of the Mersey again expands to about three times that width and is filled with alluvial flats, swamps and marshes ; which broad marshy strip has, from very early times, formed an important belt of separation between the counties of Lancashire and Cheshire.

The coast line of the area is formed for the most part of low banks or level stretches of glacial and post-glacial beds, almost the only places where the solid rock appears at the surface on the coast being at Burton Point in the estuary of the Dee ; sandstone reefs at the two angles of the Wirral Peninsula, with low sandstone cliffs (the Red and Yellow Noses) near New Brighton ; and in the Mersey estuary low rocky sandstone cliffs at Birkenhead (now masked by the graving docks), Eastham and Ince on the Cheshire side, and at the Dingle in the southern suburbs of Liverpool on the Lancashire side. The boulder clay forms cliffs 50 to 60 ft. high at Dawpool to the south of West Kirby ; and similar clay cliffs occurred at Seacombe and Egremont on the Mersey side of the Wirral peninsula,

but are now masked by the marine promenade. On the Flintshire side of the Dee, the drift covered slopes of the ridge come down very near to the narrow strip of alluvium which fringes the coast.

Liverpool Bay, and the open estuaries of the Dee and the Mersey (with the exception of the lower five or six miles of the latter), are seen to be occupied at low water with a vast area of sandbanks, the channels between which vary from time to time. Wide stretches of sand (in several places at least one mile broad) fringe the shore at low water from Southport nearly down to Liverpool; and again on the north Wirral coast, especially in the neighbourhood of Hoylake and West Kirby. Inland of the shore line a belt of dunes of blown sand occurs along the north coast of Wirral and on the Lancashire coast from a little north of Liverpool to Southport, while up to the early part of last century similar dunes occupied the sites of Waterloo, Seaforth and Bootle. A sand dune area also forms a salient feature (known as the Point of Air) on the North Wales coast just outside the mouth of the estuary of the Dee. This marginal area of blown sand which between Liverpool and Southport is estimated to cover an area of about 22 square miles, varies in width from half a mile up to two and a half miles (in the neighbourhood of Formby) and the dunes in places reach a height of 60 feet.

The *accumulation* is due to the sand carried by the prevailing westerly winds from the dried surface of the sandy shore and of the sandbanks exposed at low tide. In some parts of the coast (e.g., near Crosby on the Lancashire side, and near the Leasowe Embankment in Wirral) the dunes are at the present time subject to destructive action by high tides accompanied by strong westerly gales; in other parts (as near Blundellsands on the Lancashire coast, and near New Brighton on the north shore of Wirral) large quantities of sand have in recent years been carried inland, to the great inconvenience of the residents and local urban authorities. The late T. Mellard Reade informed the Royal Com-

mission on Coast Erosion that, according to careful measurements and observations made by him, the accumulation of blown sand on the portion of the coast adjoining Great Crosby, during a period of forty years, had caused the shore line to move seawards at an average rate of 3 ft. 6 inches per annum. The Formby salient on the Lancashire coast, which is composed of wind drifted sand, is a comparatively recent feature. According to De Rance (in the Geological Survey Memoir) there was 'about 1690, a deep-water channel close to the shore at Formby, with a sandbank outside it which gradually came nearer and nearer. At length it joined the coast, from which sand commenced to blow, so that in a short time the cultivated land, gardens, orchards and streets of Formby were entirely covered up; and in 1746 the church had to be taken down and moved inland to its present situation.' In the Formby district much attention has of late years been given to the planting of the sand dunes with 'marram' or 'starr-grass' (*Ammophila arundinacea*) and pines with a view to their stabilisation.

But while accumulation and accretion are features of certain parts of the coast, *erosion* is active on a large section of the northern coast of Wirral, and on the Lancashire coast in the neighbourhood of the mouth of the Alt. At the Liverpool meeting of the British Association in 1896, Mr. G. H. Morton gave a detailed account of the erosion which was taking place on the Wirral coast adjacent to the Wallasey Embankment, showing that at both ends of the embankment the waste then amounted to between three and four yards per annum, and that a fringe of sandhills 150 yards wide had been removed during the previous 30 years. There is no doubt that a considerable former extension of North Wirral has been carried away by erosion in still earlier times, leaving little or no traces or records. Similar erosion on the Lancashire coast near the Alt mouth is probably largely influenced by the changes in the direction of the seaward channel of that stream, which has been forced into a southerly direction

parallel to the shore apparently by the accretion of sand in the Altcar and Formby region immediately north. Recent erosive action here has led to the rapid destruction of several houses and gardens near the shore; and Mr. C. B. Travis calculates that at one point there has been a loss of about 75 yards in width within seven years, while during the same period a strip of sand dunes $1\frac{1}{4}$ miles long, 60 yards wide, and 7 yards high has been washed away.

(*c*) *The Estuaries.*

The estuary of the *Dee*, which was formerly freely navigable up to Chester, has since the 12th or 13th century been silting up extensively, so that the port activities were transferred successively to Shotwick, Neston, and Parkgate, lower down the estuary. An effort to conserve and improve the navigation, and at the same time to reclaim some of the sand and mudbanks in the upper reaches of the estuary, was commenced in 1733, and this has resulted in the reclamation of several square miles of land now devoted to grazing and agricultural purposes. Through this area the Dee runs in a straight cut artificial channel as far as Connah's Quay. A great expanse of saltings or sea marsh is now in process of natural formation between Neston and Burton Point, to the north of the protected reclaimed area. In the mouth of the estuary stand the three small islands of sandstone known as Hilbre, Middle Eye and Little Eye, which at low water are connected with the shore at West Kirby by an expanse of almost dry sand.

The estuary of the *Mersey* at its mouth has a waterway of from three-quarters to a mile in width for a length of between five or six miles, and then its extension inland expands into a lake-like area with a maximum width of over three miles, narrowing again as it approaches its inner limit in the narrow rocky channel of Runcorn Gap. The upper part of the estuary is largely occupied with extensive sandbanks, but the narrow neck forming the outlet to the sea is

kept clear by the scour of the tides, which run through the channel at times at a rate of five or six miles per hour. The fact that many eminent authorities consider that the Mersey is not included in the list of estuaries on the west coast, referred to by Ptolemy, has led some to the conclusion that this outlet did not exist in Roman times, but has been formed at a more recent date. They therefore sought an outlet for the River Mersey in some other direction; the most favoured being a connection with the Dee through a valley which runs across the peninsula of Wirral from the neighbourhood east of Ellesmere Port to Chester. The matter has been the subject of much discussion, and other theories to account for the supposed omission by Ptolemy have been propounded. Other authorities, however, question the accuracy of that interpretation of Ptolemy's data, and there are physical difficulties which need to be explained away before the connection of the Mersey with the Dee, and the recent opening of the present outlet between Liverpool and Birkenhead, can be confidently accepted.

It may be noted here that in the case of both estuaries deeply buried pre-glacial channels, filled with glacial deposits, have been proved to exist below their present beds. The existence of a pre-glacial channel of the Mersey running from the neighbourhood of Widnes to Liverpool was predicted by Mellard Reade from a study of a large number of borings; and during the construction of the Mersey Tunnel between Liverpool and Birkenhead, in 1885, the old channel was pierced at a depth of about 70 feet below the present bed of the river. Connected with this old pre-glacial channel are a number of drift-filled tributary channels from 40 to 50 ft. below Ordnance datum, which have been met with on both sides of the river in the course of dock excavations.

(*d*) *The Irish Sea and its floor deposits.*

That portion of the Irish Sea adjacent to the coasts of North Wales, Cheshire and Lancashire, is for the

greater part a comparatively shallow basin, the ten fathom contour line being at a distance of more than ten miles from the coast line; while the 20 fathom contour line lies 25 to 30 miles away, and extends to the north-west so as to enclose the Isle of Man. Between the Isle of Man and Ireland greater depths are met with; especially in the case of a narrow channel, running North and South, below the 50 fathom contour and reaching in one part a depth of 76 fathoms. In Liverpool Bay—the area lying off the mouths of the estuaries of the Dee and the Mersey—very extensive sandbanks occur, which are largely exposed at the ebb of the tide, the main channels between being buoyed and kept open near the bar by means of large suction dredgers.

The deposits on the bed of the Irish Sea have been investigated in the dredging expeditions of the Liverpool Marine Biology Committee, in the course of which many samples were obtained and deposited in the oceanographical department of the Liverpool University, and in the Geological Museum in Jermyn Street.*

In the shallow waters within the 10 fathom contour, more or less pure quartz sand is found (as also in the sandbanks), with small local patches of shells or mud 'which can generally be accounted for by tidal or estuarine currents, by the entrance of fresh water streams carrying down alluvium, or by the presence of littoral or sub-littoral boulder clay.' Further from the shore, as the depth increases the sand becomes more and more mixed with mud, and there are considerable tracts of shelly deposits. The deepest parts, below 50 fathoms contain 'dark bluish grey mud which is very tenacious and sets when dried into a fine clay.' No evidence was found of the nature of the rocks forming the sea floor beneath the deposit of glacial drift and the recent accumulations. Erratics of granite, Ailsa Craig eurite, serpentine, limestone,

* These deposits have been described and discussed in some of the Annual Reports of the Committee (1895 and 1896) and also in a paper by (Sir) W. A. Herdman and J. Lomas, in the *Proceedings of the Liverpool Geological Society* for session 1897-8.

silurian grits, etc., are found, some of them striated. Slaty gravel is found, as might be expected, in the shallow waters round the South coast of the Isle of Man. The sand in the eastern part of the sea is derived mainly from the Triassic areas, some of it, no doubt, by way of eroded glacial deposits.

In several localities certain special and interesting deposits have been met with; deposits of a kind for which Sir W. Herdman has suggested the term 'Neritic.' About halfway between the Calf of Man and Holyhead, and again at a spot between Ramsey and St. Bees' Head, a deposit consisting of calcareous masses 'like clinkers,' was found, consisting of sand grains and shells cemented by carbonate of lime. About two miles S.E. of the Calf, a white sand consisting almost wholly of animal remains—shells and fragments of *Pecten*, *Mactra*, *Venus*, *Cyprœa*, *Buccinum*, *Trochus*, *Balanus*, *Serpula*, etc.—was met with; while in one or two other places near the island, at depths between 10 and 20 fathoms were found great Nullipore deposits formed mostly of *Melobesia* and *Lithothamnion*. Mr. Clement Reid remarked that some of the deposits of organic origin were 'in many respects strikingly like certain parts of the Coralline Crag' formation of Pliocene age in East Anglia.

NOTES ON THE HISTORY AND ANTIQUITIES OF LIVERPOOL.

Robert Gladstone, B.C.L., M.A.

Liverpool, of world-wide fame as a sea-port, is also a place of very considerable antiquity—though it must be admitted that there are no visible evidences of that antiquity now remaining.

As a sea-port, Liverpool has, of course, always been dependent upon the estuary of the Mersey, and to local antiquaries of the last generation it was a grave annoyance that the Geography of Ptolemy (circ. 150 A.D.) appeared to ignore the Mersey estuary altogether. Ptolemy had quite a good system of latitude and longitude, and by it the positions of the places which he names can be determined pretty accurately. Unfortunately, however, not one of the names which he mentions in connection with this part of the coast-line bears the slightest resemblance to any of the names now known to us, so that precise identification is difficult. Even Ptolemy's 'Moricambe estuary' (which at first sight would seem to be a 'sure thing'), proves on investigation to be a particularly disconcerting example. According to Ptolemy's latitude and longitude, his 'Moricambe estuary' should be a certain bay in the Solway Firth which forms the estuary of the rivers Waver and Wampool,[1] and here accordingly the early English interpreters of Ptolemy[2] placed it. You will therefore find 'Moricambe Bay' duly entered up there on modern maps. But in the latter part of the 18th century other antiquaries,[3] misled largely by the

1. Also called Kirkbride Loch or Cardurnock Bay.
2. For example, Camden in his *Britannia* (1586), p. 453.
3. For example, Thomas West in his *Antiquities of Furness* (1774) and Richard Gough in his edition of Camden's *Britannia* (1789).

forgeries of Charles Julius Bertram,[4] began questioning and ' adjusting ' the latitudes and longitudes given by Ptolemy, and entered upon speculations in consequence of which they placed Ptolemy's ' Moricambe estuary ' where the well-known Morecambe Bay appears in modern maps to-day,—the map makers following blindly the wild and dangerous speculations of the antiquaries. Consequently, we have in modern maps *two* bays purporting to be Ptolemy's ' Moricambe estuary," one on the Solway Firth, and the other on the coast much lower down, neither bay having borne the name until the antiquaries christened them. Similar uncertainty prevails regarding the other local names given by Ptolemy, and the only way out of the difficulty is to return to Ptolemy's own text and to take his own figures without ' adjustment.'[5]

Supposing, however, that Ptolemy did ignore the existence of the Mersey estuary, and gave only one name to cover both the estuary of the Dee and the estuary of the Mersey,[6]—this would be quite intelligible and justifiable, for Ptolemy's work was essentially of a practical character, and the only good anchorage in those parts for sea-going ships was in Hoyle Lake,[7] near the mouth of the Dee, from which a channel (the Rock Channel) led along the Wirral Coast to the Mersey. The true outlet of the Mersey (the Formby Channel) was not used, on account of its uncertainty, difficulty and danger. In the earliest times sea-going vessels anchored in Hoyle Lake and discharged their cargoes into boats of lighter draught which took goods

4. The damage done by his forged " Itinerary " to the study of the Roman geography of Britain can hardly be overestimated. See the article on him in the *Dict. Nat. Biogr.*, and a longer account in J. A. Farrer's *Literary Forgeries* (1907) pp. 26–38.

5. T. G. Rylands " adjusts " Ptolemy in his " Geography of Ptolemy elucidated " (1893, but consisting of papers published earlier). Another " adjuster," alas, was the late Dr. H. Bradley, in the *Archæologia*, vol. 48, p. 393. An edition of Ptolemy's Geography so far as it relates to the British Isles, with facsimiles of the maps in the earliest or best MSS., is badly needed.

6. We need not pause to consider seriously the theories of those who maintain that (even in historical times) there was no " mouth " to the Mersey, but that it ran into the Dee.

7. Also called in former times—Chester Water, Chester Roads, Wallazey Lake, etc.

to Chester on the one hand, and to Liverpool on the other. The reverse process, of course, occurred in loading, the salt manufactured at Nantwich and Northwich, which came down the River Weaver and along the Mersey estuary, being an important article of export trade.

In course of time, however, the trade with Liverpool increased sufficiently to make it worth while to send the ship itself round to Liverpool from Hoyle Lake, after lightening it of cargo for other destinations. Collins, writing in 1689, describes methods which, no doubt, had been in use for centuries before his time. In his 'Coasting Pilot'[8] he gives directions for entering and anchoring at Hoyle Lake, and proceeds to inform us—'Here the great ships that belong to Liverpool put out part of their lading till the ships are light enough to sail over the flats to Liverpool. There is a channel near Formby to go into Liverpool, where is three fathom at low water on the bar, but this place is not buoyed nor bekon'd (beaconed), and so not known. The ships lye aground before the town of Liverpool; 'tis bad riding afloat before the town, by reason of the strong tydes that run here; therefore ships that ride afloat, ride up at the Sleyne, where is less tyde.'

Subsequent charts show that from 1714 onwards slight attempts were made to buoy the Formby Channel,[9] and that it was very gradually coming into use; but it was not until 1833 that the doom of Hoyle Lake and the old Rock Channel as the main route to Liverpool was finally sealed, in consequence of the thorough survey of the Mersey Bar in that year by Lieutenant H. M. Denham, R.N.[10]

In the early days, when the Hoyle Lake anchorage was in regular use, passengers from Chester and Liverpool were notified, the former by messenger, the latter by flags and afterwards by semaphore signals on

8. Published in 1693, p. 15. Collins informs us in a marginal note that at Hoyle Lake (or *Highlake* as he calls it) King William and his army embarked for Ireland in 1690.
9. It seems that Trinity House was to some extent an obstacle.
10. Afterwards Admiral Sir H. M. Denham, F.R.S.

Bidston Hill, when the vessel at Hoyle Lake was loaded and ready to sail. They embarked, and *vice versa* disembarked, by means of row-boats from the shore along the Hoyle Lake, and, as might be expected, constantly dropped by accident small articles into the water when paying the boatman or when climbing on or off the vessel. Consequently we find that the whole of the shore there below high-water mark is (so to speak) littered with every kind of little object that passengers might accidentally let fall on such an occasion. Large collections of these articles are in the Liverpool Museum and in the Grosvenor Museum at Chester. Not only have flint implements been found on the shore, but also ancient jewellery, Roman *fibulae* (brooches), buckles and fastenings of every description, and coins, commencing with a silver drachma coined at Carthage, continuing with Roman coins from A.D. 41-54 onwards, followed by Saxon, Danish, English, Scottish and Irish coins, and concluding with those of the 18th century.[11]

For fully 1,700 years, therefore, Hoyle Lake did good service as the anchorage for the Dee and the Mersey, but it is now completely silted up, no doubt in consequence of the extensive interference with the estuary of the Dee commenced under an Act of Parliament of 1733 (6 Geo. II, c. 30), against the passing of which the Corporation of Liverpool protested in vain, on the ground that the proposed alterations ' would tend to the prejudice of this port, and more especially to destroy Hoyle Lake.'[12]

It is now easy to understand why, for Customs purposes, Liverpool was always regarded as ' a creek of the Port of Chester,'—a description which, as the trade of Liverpool increased and the trade of Chester decreased, was strongly objected to by the Liverpool Corporation. The objections were, however, unavailing until 29 October, 1658, when the Corporation

11. See the list in Rev. A. Hume's *Ancient Meols* (1863) pp. 290–5.
12. See Sir J. A. Picton's *Liverpool Municipal Records*, vol. 2 (1886), p. 92, and Hume, *op. cit.* pp. 42 and 46.

obtained an award by which practically the whole of the Hoyle Lake anchorage was placed under the Liverpool Customs Officers.[13] This award, after the Restoration, was duly confirmed on 12 December, 1660.[14]

Before leaving the subject of the ancient navigation of the Mersey, it is amusing to note that when lighthouses were first introduced in 1671, the Mayor of Liverpool and other notables wrote to the Liverpool Members of Parliament instructing them to oppose the establishment of lighthouses on the ground that ' those lighthouses will be of no benefit to our mariners, . . . and also be a very great and unnecessary burden and charge to them.'[15] It was not until 1761 that the erection of lighthouses at Hoyle Lake and at Formby was authorised by Act of Parliament.

Liverpool owes its origin as a sea-port to the little ' pool ' or creek, long since filled up, which entered the Mersey where the Custom House now stands,[16] and ran inwards along what is now Paradise Street, Whitechapel, and the Old Haymarket.[17] Along the Lancashire shore of the Mersey it was the only refuge from the swift tides and often rough waters of the estuary. At the upper end of this creek, near what is now Tryon Street, five Roman copper coins (circ. 320 A.D.),[18] with other coins of later date and the remains of a boat, were found during excavations in 1898.

From this ' pool ' or creek the latter part of the name ' Liverpool ' is, by general admission, derived. Regarding the other part of the name, however, there is the widest difference of opinion. In early records this part of the name occurs as—' Liver,' ' Lither,' and ' Lever,' and no explanation has yet been put forward

13. Picton's *Records*, vol. 1 (1883), p. 154.
14. Thomas Baines's *Liverpool* (1852), p. 242 note.
15. Hume, *op. cit.* pp. 42–3 note.
16. Formerly the site of the famous Old Dock, opened 1715, filled up 1826–7. The formation of the Old Dock stopped up the mouth of the Pool.
17. The Pool is well shown in the large model of Liverpool in 1650 in the Liverpool Room at the Museum. It was made by Augustus Harding in 1853, and, though not quite correct in all its details, gives an excellent general idea of the old town.
18. Now in a case at the Liverpool Museum.

which will satisfactorily account for all of them.[19] But one thing at least may safely be said, namely, that the name 'Liverpool' has no connection whatever with a wholly suppositious bird called a 'liver.' The bird which forms part of the arms of Liverpool should undoubtedly be an eagle,—the eagle of St. John the Evangelist, as engraved on the ancient corporate seal of Liverpool, but unfortunately so badly engraved that the civic authorities in later days supposed it to be a cormorant.[20] Thus, when the Corporation applied in 1797 for a grant of arms, the bird was stated to be a cormorant, and the grant accordingly records it as such.[21] It appears, further, that a local name for a cormorant, or a 'shoveller' (we must not be too precise), was 'lever' or 'liver' and consequently local etymologists, with more daring than discretion, assumed that this was the derivation of 'Liver' in 'Liverpool.'

The eagle of St. John on the ancient corporate seal was adopted in compliment to King John, who, by letters patent dated 28 August, 1207, first constituted Liverpool a borough. But Liverpool, of course, existed long before this. In Domesday Book, Liverpool is not mentioned by name, but is no doubt one of the six unnamed subsidiary manors stated to be attached to West Derby. The first specific knowledge that we have of Liverpool is that about the year 1165 it was granted, with other lands, by Henry II to Warin de Lancaster as a salary or fee for his services as falconer. Warin de Lancaster died about 1192, and was succeeded by his son Henry, commonly called Henry FitzWarin or Henry de Lea. On 10 October, 1199, King John confirmed to Henry FitzWarin all his lands *with the exception of Liverpool*, doubtless because he saw the advantages of

19. Lyrpool, which is occasionally found, is merely a popular abbreviation, just as Everton was shortened into Yerton, Wavertree into Wa'tree, etc.

20. See the frontispiece. The ancient seal was destroyed in 1743, possibly by mistake, and a wretched copy preserved, which is still in use. How this came about, is too long a story to tell here.

21. The error is corrected in the arms of Liverpool Bishopric (1882), in which an eagle duly figures.

the place as a sea-port and wished to acquire it. Negotiations were evidently protracted, for it was not until 23 August, 1207, that King John made an exchange of lands with Henry FitzWarin and obtained Liverpool. Five days later, as has been stated above, King John created Liverpool a borough.

But although Liverpool was now a borough, the manorial rights, which Henry FitzWarin and his father had possessed over it, still continued to exist in the hands of King John and of those who succeeded him as lords of the manor of Liverpool. These rights were of very practical importance and value, comprising the town dues, the market tolls, the ferries, and so forth. The general practice was for the lord of the manor to lease these rights to the municipality for longer or shorter terms of years; but squabbles constantly occurred, especially when the time came for renewal, and it was not until 4 February, 1777, that the Corporation succeeded in purchasing the manorial rights from the Earl of Sefton for the remarkably moderate sum of £2,250.

Similarly, Liverpool was originally part of the parish of Walton-on-the-Hill, and disliked the position intensely, more especially when it began to find its feet as a municipality. It even went so far as to deny the fact occasionally, and paid the Walton church-ley or rate very irregularly, usually under compulsion. In the earliest times, Liverpool had only a tiny chapel-of-ease, the Chapel of St. Mary of the Quay, which stood where the street is now, close to the tower of St. Nicholas's Church, then on the edge of the sea-shore. This little stone chapel was extremely old,—Blome, writing in 1673, calls it ' a great piece of antiquity,'—possibly it was of Saxon origin. At the Reformation it was seized by the Commissioners and was sold to the Corporation in 1553, apparently for £1. Its subsequent fate is lamentable. It was used successively as a warehouse, a school, a dwelling-house, an office for the ferry-boat service, and lastly as a tavern. Finally, in 1814, it was sold by the Corporation for £1,760 to

the ecclesiastical authorities, who incontinently pulled it down. In such ignominious fashion departed Liverpool's greatest ' piece of antiquity.'

Very naturally, after Liverpool was made a borough and began to grow, the tiny chapel of St. Mary of the Quay became entirely inadequate to the increased population. Negotiations for the establishment of a larger chapel were commenced in 1353, and in 1362 a new and much larger chapel (still under Walton) was dedicated to St. Nicholas. This chapel, altered and enlarged beyond all recognition, still exists, and is the official Corporation church, after having been temporarily supplanted from time to time by other churches since demolished.

But although, after 1362, Liverpool had an adequate chapel of its own, the rights of Walton rectory, to which it belonged, were carefully reserved, and it was not until 1699 that Liverpool obtained an Act of Parliament constituting it a separate parish, due compensation being paid to the rector, vicar, and patron of Walton. The printed ' case ' put forward by the Corporation in support of the Bill is an amusing document, as the following extract will show: Liverpool, it says,—' was formerly a small fishing town; but many people coming from London, in the time of the sickness, and after the fire, several ingenious men setled in Leverpool; which encouraged them to trade to the plantations and other places; which occasioned sundry other tradesmen to come and settle there; which hath so enlarged their trade, that from scarce paying the sallary of the Officers of the Customs, it is now the third part of the trade of England, and pays upwards of £50,000 per annum to the King. And by reason of such encrease of inhabitants, many new streets are built, and still in building; and many gentlemen's sons of the counties of Lancaster, Yorkshire, Derbyshire, Staffordshire, Cheshire, and North Wales, are put apprentices in the town. And there being but one Chapel, which doth not contain one half of our inhabitants in the summer, upon pretence of going to the Parish Church, which is two long

miles, and there being a village in the way, they drink in the said village; by which, and otherwise, many youth and sundry families are ruined. Therefore it is hoped the Bill may pass, being to promote the service of God.'[22]

When Liverpool was constituted a separate parish, the Corporation put forward a scheme for the erection of a new parish church on the site of the Castle, which then occupied practically the whole of the open space where the Queen Victoria Memorial now stands. The Corporation had always viewed the Castle with disfavour. In the first place, the Castle was a 'liberty,' over which the Corporation had no control, and complaints arose from time to time that 'undesirables' had practically taken sanctuary there. Next, the retainers of the Molyneux family, who from 1446 onwards were Constables of the Castle, were a menace to the corporate authority, as were also the retainers of the Stanley family, who occupied the Tower in Water Street, and used it as a sort of depot in connection with their Kingdom of the Isle of Man. We may note in passing that the Corporation purchased the Tower in 1775 and pulled it down in 1820.

Returning to the Castle, in later years the Corporation coveted the site, with a view to what in modern parlance is termed 'development.' In other words, the Corporation wanted to put a market and shops on the site, in order to make money out of it,—the idea of a church being by now quite subsidiary and (as it were) a species of stalking horse. To cut a long story short, the Corporation got its way, but the Crown insisted that the church should be built. In 1715, an Act of Parliament gave authority for the Castle to be handed over to the tender mercies of the Corporation. The actual transfer took place in 1718, and bit by bit the Castle was taken down, the church (St. George's) not being completed and consecrated until 1734, by

22. See the facsimile in H. Peet's *Liverpool Vestry Books*, vol. 1, facing p. 410.

which time very little, if anything, of the Castle can have remained standing. Finally, to complete the chain of futility, the church itself was closed at the end of the year 1907, and was subsequently taken down to make way for the Queen Victoria Memorial.

The Castle was erected in 1235, or soon afterwards, for on 19 January of that year the King licensed William de Ferrers, Earl of Derby, to levy an ' aid ' on his men for the purpose of building it.[23] No satisfactory views or plans of it are in existence. It stood on a rocky plateau, long since levelled, some ten or twelve feet higher than the present level of the square. Leland, writing about 1540, calls it a 'castelet.'[24] From a report made to Queen Elizabeth in 1559 we learn that it was regarded as ' a small thing,' standing on a rock, roughly square, less than sixty yards the longest way inside, with a square gatehouse facing Castle Street at one corner, and with round towers (one of them bigger than the other two) at the other corners.[25] We know also that it contained a keep, a hall, a chapel, and subsidiary buildings and offices.

The most interesting incidents in the Castle's history occurred during the Civil War. First of all, it was taken, along with the town, by the Parliamentarians, apparently on 3 April, 1643, and Colonel John Rosworm, a Dutch engineer, was sent from Manchester, to improve the fortifications of Liverpool.[26] He spent five days there, and from his plans elaborate entrenchments and ramparts were made round the town, including a

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23. Patent Roll, 19 Hen. III. (45), m. 15. In the printed *Calendar* (p. 89) the editors are evidently unaware that " firmare," in connection with fortifications means to *construct*, not to *repair* (" refirmare ").

24. John Leland's *Itinerary* (ed. L. Toulmin Smith), vol. 5 (1910), pp. 40–1

25. *Hist. Soc. of Lancs. and Chesh.*, vol. 59 (1908), pp. 162–4.

26. The precise date is uncertain, but the writer has constructed an itinerary of Col. Rosworm, from which it would appear that Liverpool fell on Monday, 3 April, and that Rosworm was there from the 4th to the 8th.

deep moat, cut in the solid rock, round the Castle.[27] Next, Prince Rupert, after a severe struggle, succeeded in taking Liverpool and the Castle on the night of 14 June, 1644, and sent for another Dutch engineer, Sir Bernard de Gomme, who made plans for improving further the defences of Liverpool, including extensive alterations of the Castle. Time, however, did not admit of much being done, for on 16 August of the same year Colonel Rosworm was again summoned to Liverpool, and had the unusual experience of attacking his own fortifications. The town held out until 1 November, when the garrison mutinied, and a general surrender of the town and Castle followed.

At the commencement of this article it was admitted that no visible evidence of Liverpool's antiquity now remains. That the Castle, and in a less degree the Tower, should have been removed, in both cases by the Corporation, is deplorable. The ecclesiastical authorities are to blame for the destruction of the little Chapel of St. Mary of the Quay,—by far the most ancient building of them all. The only building of any importance now remaining in Liverpool that can in any sense be termed 'old,'—and it only dates from the year 1718,—is the old Blue Coat School building in School Lane, which formerly housed a charity-school for boys and girls, now removed to splendid new buildings at Wavertree. The building in School Lane in recent years has been renamed 'Liberty Buildings' by its proprietor, but by most Liverpool citizens it is still spoken of as 'The Old Blue Coat School.'

As one of Liverpool's oldest streets, Tithebarn Street is worthy of a passing notice. In it stood the old tithe-

27. The absence of all mention of a moat in the Report of 1559, and the complaint in the *Moore Rental* (1668) about the "rubbish" from the Castle trench obstructing the adjoining streets (W. F. Irvine's ed. p. 107, T. Heywood's ed., p. 84), point clearly to this conclusion. The *fossa* or *fossatum* often mentioned in records of the Castle, was not a trench but a turf or earthen ramp or bank (see *Town Books*, vol. 1, p. 598 under the word *diche*). It is noteworthy that "dyke," "moat," and "ditch," should each have two directly opposite meanings. "Dyke" means a wall or a trench. In Scotland, "moat" means a mound. And in parts of Ireland, "ditch" means a turf wall, as in the proverb—"The best hurlers sit on the ditch."

barn, in which the tithe-corn was stored, and as the ancient method of collecting the tithe-corn, before commutation into money became the general practice, is now almost forgotten, it may be well to state what the ancient method was. When a farmer had cut his corn, and had made the sheaves into stooks (or shocks), he was not allowed to remove them from the field until the tithing-man had selected one in every ten stooks. He marked each stook that he selected by thrusting into it a twig, and he could select any stook he liked, provided that he did not exceed the total number of one-tenth of the whole. It was therefore to the farmer's interest to make the stooks as equal as possible. When the tithing-man had gone, the farmer was at liberty to remove his stooks, but he had to leave on the field the ' twigged ' stooks.[28] These were duly taken away by the tithe-cart and were lodged in the tithe-barn.

Lime Street was formerly called Limekiln Lane, from the extensive lime-burning which was carried on there until about 1810. Fuel was cheap in the shape of coal from Prescot, while the limestone was brought in sailing-boats from the Welsh quarries. The method of landing the stone was primitive. At high-water the boats came as far in shore as they dared, and then the crew threw the cargo overboard into the water. At low-water, carts came down and took the stone to the kilns. This process of throwing the stone overboard was, however, found to be highly dangerous to small boats, which in rough weather were apt to get their bottoms stove in on the stones. Consequently, on the shore well below high-water mark, a ' perch,' that is a tall and strong post with cross-bars at the top to attract attention, was set up, and limestone was allowed to be ' dumped ' there and nowhere else. This is the explanation of the ' Limestone Perch,' marked in some

28. This sense of " to twig " seems to be unknown to the editors of the *New English Dictionary*. Hence appears to have arisen the slang sense of the word, for example—" I twigged him at once " means " I had him marked or recognised at once."

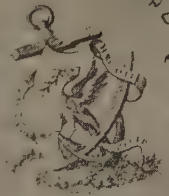
of the older maps of Liverpool, standing in the water near where the northern end of the Landing Stage now is. Some writers have supposed that the 'Limestone Perch' was a mysterious sea-mark built of limestone![29]

Of actual industries, Liverpool, in the olden time, had virtually none,—beyond supplying its own wants in the old-fashioned way. It was primarily a port and a market. John Leland, writing about 1540, tells us that the dues and charges were low at Liverpool, and that consequently there was plenty of good merchandise there, mentioning particularly Irish yarn, which was bought up by traders from Manchester.

In the 17th century there was a considerable manufacture of salt, not at first actually at Liverpool, but at Dungeon Point, near Hale. Here there were, at least as early as 1697, extensive salt-works which carried on a successful competition with the salt-makers at Northwich. The rock-salt was brought from Northwich, either in boats down the River Weaver and across the Mersey, or by road and across the ford from Weston Point. It was dissolved in seawater from the Mersey, and coal was cheaply brought from Prescot in panniers on the backs of a constant procession of donkeys, driven by boys with picturesque red jackets. So successful were the Dungeon Works that in 1697 the Northwich salt-makers issued a formal protest, alleging that their rivals held an unfair advantage, owing to their cheap fuel and the use of seawater, from which, of course, they obtained a certain amount of additional salt.[30] The salt was largely shipped from Dungeon to the fisheries in Cornwall, and the vessels

29. Another notable "perch" was on the rocks where the New Brighton lighthouse now stands. This gave the name "Perch Rock Battery" to the fort close by. The name has nothing to do with a fish, as has sometimes been supposed.

30. The complaint of the Northwich manufacturers is amusingly set forth in a rare pamphlet with the following long title:—"Reasons for continuing the Duty of eightpence upon each one hundred and twenty pounds weight of Rock Salt, without allowing a draw-back upon refining the same; by comparing the Brine-Salt made at Northwitche in Cheshire, with the Salt-Rock refined at the Dungeon near Leverpoole in Lancashire. Printed in the year 1697." (No place, nor printer's name, small 4to, pp. 13.)



2695

No 0538 **Liverpool** 4 July 1793

G 6062

On demand, I Promise to pay to George Sterling or Bearer **Ten Pounds**, according to an Act of Parliament passed in the thirty third Year of the Reign of his Majesty King George the Third.

For the **CORPORATION** of **LIVERPOOL**.

Ten

Geo. Case

Ed. John Wilson, Actuary

Ed. B. Redish

R 6549

brought back china-clay, which was landed in Liverpool and was used in the Liverpool potteries, then coming into prominence.

Of the productions of the famous Liverpool potteries a splendid collection is shown in the Liverpool Museum. To the ordinary observer the earlier examples appear quaint rather than beautiful, but in later years an extraordinarily high level of excellence was attained. Much could be written on this subject, for example regarding John Sadler, of Liverpool, who invented the art of printing on pottery, and of Richard Chaffers, once a serious rival of the great Wedgwood. The best known of the Liverpool potteries was the Herculaneum Pottery Company, formed in 1796, and wound up in 1833, the works dragging on till 1841, when they died a natural death, being killed, it is said, by the more suitable coal which the Staffordshire potteries possessed.[31]

One privilege, apparently unique in the case of municipalities, the Corporation of Liverpool enjoyed for a while, namely that of issuing its own 'bank-notes.' Authority to do this was granted by Act of Parliament in 1793,[32] during a period of financial panic, the total amount of the issue being limited to £300,000. The notes were of the following denominations,—£5, £10, £50, and £100. The copper-plates from which the notes were printed are preserved in the Public Library, with the exception of the plate for the £10 note, which appears to be missing, and for this reason an illustration of the £10 note accompanies this article.[33] The notes, having served their purpose, were withdrawn from circulation in 1796.

Thus far we have spoken,—it is feared in a very desultory and sketchy manner,—of features in the

31. Those interested in this subject should not fail to consult Mr. Peter Entwistle, Assistant Curator of the Liverpool Museums, who has made the subject of the history of the Liverpool potteries his own.

32. 33 Geo. III. c. 31.

33. This note was shown in the Liverpool Historical Exhibition of 1907 (see the Catalogue, p. 147). An excellent account of the Liverpool Notes forms chapter xi of John Hughes's "Liverpool Banks and Bankers" (1906). See also Touzeau's *Liverpool*, vol. 2, pp. 636–40.

history of Liverpool proper. To deal with the sudden expansion of the town which began in the latter half of the 18th century, the terrible overcrowding which followed, the various Improvement Acts,[34] the subsequent extensions of the town, incorporating into itself, one after another, almost all the adjoining townships,—would be impossible within our prescribed limits, and in any case would be tedious to the general reader. Each of these townships has an interesting history of its own, quite apart from that of Liverpool, and it must suffice here to touch lightly upon but a few of them.

Undoubtedly the most important addition to Liverpool was Toxteth Park, once an ancient deer-park, and in its day as lovely a tract of land as could be found anywhere. King John enlarged the Park by adding to it the adjoining township of Smithdown. In 1593, the deer were killed off or removed, and the Park was cut up into farms. Some idea of its former beauty may be obtained by visiting Sefton Park and (in a less degree) Prince's Park, both of which were formed out of it. In the 17th century it became a great place of refuge for Nonconformists, presumably because, the Park being 'extra-parochial,' it had no parish church for non-attendance at which they could be punished.[35] These Nonconformists built themselves a chapel, 'The Ancient Chapel of Toxteth,' about 1618, which was rebuilt in 1774, and is still standing. Its first minister was Richard Mather, notable more particularly for the important part which he and his sons played in the religious history of America, whither he emigrated in 1635. An eminent native of Toxteth was the famous but unfortunate astronomer, Jeremiah Horrocks, who died there in 1641 at the early age of twenty-three.

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34. One of the most important improvements (now forgotten) was the making of "The Great Tunnel" through the solid rock, by means of which the "Moss Lake," a large expanse of swampy land, lying at a high level, round about and including Abercromby Square, was drained and made fit for habitation. This took place in 1809.

35. The parish church of Toxteth Park, if it ever had one, was the church at Lancaster, attendance at which, by the inhabitants of Toxteth Park, was obviously impossible.

West Derby, now partly in Liverpool, which has given its name to the great Hundred of West Derby, comprising such a large part of South Lancashire,—once possessed a castle of great antiquity,[36] which was taken down about the time that Liverpool Castle was built. The old West Derby Court House, built in the 17th century, with interesting internal fittings and furniture, still survives, and has recently undergone much-needed repairs. The district seems to have been the first in which rich Liverpool merchants built themselves real country residences, being attracted no doubt by the proximity of the great houses of Croxteth and Knowsley.

Included now within Liverpool are the 'Calderstones,' which stand at the junction of the townships of Wavertree, Allerton, and Little Woolton. These megalithic remains consist of big logs of the hard local red sandstone, and bear spiral and 'cup and ring' markings, as well as modern initials and outlines of feet. A few of the stones are in their original positions, but some which were lying about in disorder were set up so as to form with the others a supposed 'Druid's Circle,' in 1845, when an adjoining landowner put a low wall and railings round the stones.[37] About 1765, some rude urns of a cinerary type were dug up near the Calderstones, but were (apparently) neglected and destroyed. They are said to have been very similar to the urns dug up at Wavertree, which are now in the Liverpool Museum. The Wavertree urns are of the rudest workmanship,—in fact they closely resemble extremely badly-made flower-pots,—and the present writer is of opinion that neither they, nor many other such urns which he has examined can safely be taken to be fair specimens of the actual pottery in daily use by the people who made the urns. In all probability these urns are conventionalised and degenerate types

36. It stood near the church, from the top of the tower of which a good view of the outlines of the foundations can still be obtained.

37. See R. Stewart-Brown's *History of Allerton* (1911), pp. 133–51, and a paper by C. R. Hand in the *Trans. Hist. Soc. of Lancs. and Chesh.*, vol. 67 (1916), pp. 1–6 and frontispiece.

of pottery which had come to be regarded as 'the correct thing' for funerals, and the same may be said of the rude 'cups' or 'incense-burners' and the weapons often found with such urns. The natural tendency would be for the kinsmen of the deceased to keep the really serviceable pottery and weapons, and to use rough and perfunctory makeshifts for the funeral, just as in China representations and models are made in paper and cardboard of the deceased's effects, which are ceremoniously committed to the flames. Possibly, too, sumptuary laws, as in the Roman Twelve Tables, forbade the wasting of really useful or valuable articles at funerals.

Adjoining the Calderstones is the township of Little Woolton, which, strangely enough, is a great deal larger in extent than its fellow township of Much Woolton. The explanation of this anomaly is that a considerable portion of Little Woolton was long ago a separate township, which, if deducted from Little Woolton now, would leave it smaller than Much Woolton. Both the Wooltons belonged, before the Reformation, to the Knights Hospitallers, and constituted their chief possession in Lancashire. They had not, however, a house or 'preceptory' there, but only a steward's office. The old School House, in School Lane at Much Woolton, long since disused as a school, is stated to have been built in 1610, and is claimed to be the oldest elementary school building in Lancashire.

Another interesting township, now part of Liverpool, is Childwall, which has a very ancient church, but greatly altered, and deprived of its heraldic stained glass and carved wood-work, of which fortunately records survive. The name used often to be written, more correctly, as Childwell.[38] The 'well' explains itself, while 'Child' seems to represent the Old Norse

38. Not that this matters much, if at all, for in Middle English a well is "walle," and in Lowland Scots the name for a well (but preferably a spring) is "wall" to-day.

'Kelda,' a spring.[39] The reason for the name is obvious, for in a field not far from the church was formerly a large stone basin or small pond lined with masonry, in which boiled up a remarkably powerful spring of water. This is shown on many of the older maps as 'The Monks' Bath,'—an absurd name, for there never were any monks at Childwall. This spring has been dry for many years, having been drained by the deep well at the Dudlow Lane Waterworks. When the writer last saw 'The Monks' Bath' some years ago, it was being rapidly filled up with stones and rubbish from the fields.

Mention must be made of the township of Speke, just outside the Liverpool boundary, beyond Garston. It is famous for that admirable example of moated black-and-white architecture,—Speke Hall, for centuries the residence of the Norris family. The main building was commenced in 1490, superseding a much older structure.[40] In former times Speke must have formed an ideal country estate, situated as it is near the shore of the wide sea-lake constituted by the upper waters of the Mersey estuary, with a splendid view of the Welsh hills beyond.

This great lake of the upper waters of the Mersey estuary, so Leland tells us, was known in his time as 'Runcorn Water' down as far as Liverpool.[41] It abounded with fish of all kinds, sea-trout in particular being so plentiful that not only were all the towns for

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39. Presumably the "Ch" in Childwall was originally *hard*, as the name is found spelled with a "K," and is sometimes written "Cheldewell." Compare the 13th century "Mikelkeldwelle" in Dumfriesshire (Drumlanrig MSS., in Hist. MSS. Comm. 15th Rep. App. Part 8, p. 40, No. 71). Also in Cowell's *Interpreter* (ed. 1727), in the list of Latin names of places. "Centum Fontes" is given as the Latin equivalent of "Hundreds Kelde." The standard etymologists are not very helpful on this subject. The Scandinavian "kelde," the German "quelle," and the English "well," seem and mean fundamentally the same. Thus "Keldwell" would appear to be a tautology or repetition of the same thing in different languages, or rather in different branches of the same language.

40. See H. Winstanley's paper on Speke Hall in *Trans. Hist. Soc. of Lancs. and Chesh.*, vol. 71 (1920), pp. 1–20.

41. Leland's *Itinerary* (ed. L. Toulmin Smith), vol. 5 (1910), pp. 40–1.

twenty miles round fully supplied, but quantities were used as food for pigs.[42]

Farther along the beautiful estuary is the township of Hale, famous for its Duck Decoy, and for its local giant, the ' Child of Hale,' by name John Middleton, 9 ft. 3 ins. in height, born in 1578, and died in 1623. At the head of the estuary stands Widnes, now an inferno of chemical industry, but not so long since renowned for its woods and for a picturesque hostelry noted for its eel-pies.[43]. Runcorn, too, in those days was a fashionable sea-side place for bathing, patronised in the summer by the well-to-do families of Liverpool.

All these rural amenities are gone or fast going, and in their place we have huge and unsightly chemical and gas works, factory chimneys, warehouses, docks, vast petroleum reservoirs, clanging tramways, shunting yards, railway sidings, and shrieking engines. Truly we pay a heavy price for what is called ' civilisation.'

(In the above article the writer has endeavoured to avoid matter readily accessible in the ordinary guide books to Liverpool, published for example by Messrs. Littlebury Bros. (for the Corporation), and by Messrs. Philip, Son & Nephew. A special handbook on ' The Port of Liverpool ' is published by Messrs. Littlebury for the Mersey Docks and Harbour Board. Those taking a more serious interest in the history of Liverpool should consult the Catalogue of the Liverpool Historical Exhibition of 1907, and especially the ' Liverpool Catalogue,' an elaborate bibliography published by the Corporation in 1908. Since that year many further publications on the subject have appeared. Among these may be mentioned—' Liverpool in the Reign of Queen Anne,'' being the Rate Book for 1705 and 1708 (1908) ; the Parish Registers of St. Nicholas

42. Norris Papers (Chetham Soc., vol. 9), pp. 37–8.
43. C. Poole's *Old Widnes* (1906), pp. 56–7. In justice to the chemical manufacturers of Widnes, it must be admitted that the atmosphere there, which some years ago was a byword, is now much improved, the smells being turned into hard cash.

(1909) ; and the Liverpool Vestry Books, 2 vols. (1912-1915), all edited by Henry Peet, M.A., F.S.A. ' The Rise and Progress of Liverpool from 1551 to 1835,' by James Touzeau, 2 vols. (1910). An admirable account of Liverpool, with authorities, by Prof. Ramsay Muir, M.A., is in vol. 4 (1911) of the Victoria County History of Lancashire. Several important papers on Liverpool subjects have appeared in the Transactions of the Historic Society of Lancashire and Cheshire since the date of the publication of the ' Liverpool Catalogue ' (1908) referred to above. Last, but most important of all, is Volume I of the Liverpool Town Books (Municipal Records), edited by J. A. Twemlow, B.A. (1918). Volume II, bringing the records down to the end of the reign of Queen Elizabeth, is now in the press).

A NOTE ON THE ARCHITECTURE OF LIVERPOOL.

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In the first half of the nineteenth century Liverpool must have been a place of considerable social and intellectual distinction. It not only led England in the culminating phase of classical architecture, but it commissioned and built St. George's Hall,—the noblest and finest piece of Greco-Roman architecture in Europe. Schinkel's great Museum in Berlin, the nearest to it in scale and general conception, is uninspired in comparison. These things are not accidents. The emergence of a single building might be, but not of a group erected during some thirty years or more. They are indeed a sure symbol of the culture of their time just as much as the new stores in Church Street, like Messrs. MacSymons' or Woolworth's or the University buildings are of the culture of to-day. In Liverpool we are very conscious of this fact. We have recently obtained a special Act of Parliament, which no other town yet possesses, enabling the town to control the façades to its streets. We mean therefore to do well, we have indeed all the civic virtues, but the first building produced under the new Act is the grocers' store, already mentioned. There it is, next to that of the early nineteenth century Athenæum Club, so that the work of that and the twentieth century can be readily compared.

But if we are to take a short general survey of Liverpool architecture, we must do it on some definite plan either of time or space. Let us take it by time

first, and note the districts built up at definite periods and then return, if space is left, for the consideration of special buildings.

Although Liverpool is said to have received a charter from King John, seven centuries ago, there is practically no work in the town earlier than the eighteenth century, and not very much of that. The chief eighteenth century remains are the Old Blue Coat Hospital buildings at the back of Church Street, built in 1717, and the Town Hall built in the middle of the century. The first is a Queen Anne group built, like a Cambridge College, round a courtyard and showing Dutch influence, which probably reached Liverpool via Hampton Court; the oval second floor windows over the long first floor ones being very reminiscent of round ones in Wren's famous Fountain Court. The Town Hall, at the head of Castle Street, was designed by the famous John Wood who gave to England its one architectural city, eighteenth century Bath. Though the building has been enlarged and altered, first by his son, after a fire, and again in the nineteenth and twentieth centuries, it still retains both in the stately shapes of its fine reception rooms on the first floor, and in its furnishing and decoration the elegant, easy, gentlemanly flavour of the eighteenth century. Apart from these two buildings, there are only a few fine old merchants' residences in Duke Street and the neighbourhood, now used as warehouses, and the walls of a slave prison. It is not certain whether the Goree Piazzas, along the river front, are as old as the eighteenth century, but they certainly are in the eighteenth century manner of building, and local tradition says that slaves were exposed for sale in their arcades. Curiously enough, there is still a very finely carved wooden tiger with a negress upon its back (which ought to be in the local museum) to be seen above their arches.

If eighteenth century buildings are scarce, all the characteristic elegance of that century is to be seen in Rodney Street, built in the first decade

of the nineteenth. Here the houses with their general similarity, but difference in detail of doors and balconies, have that well-tailored appearance good eighteenth century work always gives. The street is the most distinguished residential one in the town, having, with the exception of a couple of modern blots upon it, a singular unity and completeness, which is no doubt helped by the present unity of its occupation —the medical and allied professions. Its equal is only to be found in Dublin or New England. Thence outward beyond Rodney Street is a whole residential district built up in the middle of the nineteenth century, and corresponding to Bloomsbury in London, in which the eighteenth century ideas of politeness and non-ostentation in the exterior of town residences still hold, though the work is all the while getting a little heavier handed. The best of this mid-nineteenth century building is to be seen in the solid strength of Abercromby Square and in the more varied lighter plaster houses of Falkner Square. Further out again, to finish the domestic building, we pass late nineteenth century villadom at its height in its bright red or yellow machine-made bricks and bay windows along Princes' Avenue on the way to Princes' and Sefton Parks. Round these parks are further late nineteenth century houses mostly trying to look like country houses and failing a little dismally, while further out still are the districts Mossley Hill, Allerton and Woolton, built up about the same time, where, however, the larger residences are largely hidden from the vulgar by the high stone walls, brought about by a desire for respectability and an easily accessible quarry. A pleasanter district of pleasanter houses is defined by St. Michael's Hamlet, Aigburth, Fulwood Park and Cressington along the river, but this is now nearly absorbed in the full tide of twentieth century rows of the bright little red houses which grew up with such marvellous rapidity before the war. Roughly, this has been the more fashionable expansion of Liverpool during the nineteenth century, but there are elsewhere of course left

dry by the rising tide of villadom—and much thankfulness is given for them—oases of pleasanter early nineteenth century houses which would correspond to late eighteenth century ones in London. These are to be found at Waterloo, along Everton Brow, in Fairfield and West Derby, as well as in the Bloomsbury district, east of Rodney Street, already mentioned. These inner and older residential neighbourhoods, save Waterloo, are all encircled now by the great new circumferential road round Liverpool called the Queen's Drive and by the new suburbs of small government houses, which cling to it.

The Queen's Drive, however, both in its conception and in the detail of its creation, especially in the way in which it connects with Sefton Park, is one of the finest gifts the imagination of Mr. Brodie—a city engineer with that rare endowment—has given to the town.

Let us return now to the more monumental building of the mid-nineteenth century, when the eighteenth century Palladian tradition of the Town Hall gave way to the full Roman and Greco-Roman feeling. This building period is Liverpool's real, if locally unappreciated, glory. We find the chief group of such buildings round St. George's Hall forming with it what, in modern town planning jargon, is called a civic centre, or the possibility of one, of no mean order. The Hall, which was the result of two competitions and the gentlemanly refusal of the then Corporation Surveyor to oust the architect and to carry out the work himself, was designed, as everyone knows, by a young man, Harvey Lonsdale Elmes. How a young man in the late twenties could be so imbued with the delicacy and refinement of classical detail that he could clothe his very original composition of a great central hall and two subsidiary ones in such a perfect garment of combined refinement and splendour is only to be explained, if explained at all, by the accumulated and unbroken tradition of fine architecture which had come down to us from the Renaissance. Elmes, as his own work in

Gothic shows—the School in Shaw Street—was really untouched by the Gothic revival. So austere and remote is the Hall externally that to-day it seems th work not only of a different generation, but of a different race. It certainly must have been a different race of human beings which added that strange mixture of upstart stone piers, curved battering stone walls, intestinal iron railings, and jumping statuary, officially known as St. John's Gardens, but more commonly called the Stone Yard, behind the great range of square Corinthian columns rearing their massive architrave high against the sky, which forms the back of the Hall. The interior, including the beautiful and graceful concert hall, was finished by another great nineteenth century architect, Professor C. R. Cockerell, who gave us the stately Bank of England, in Castle Street, and the Liverpool, London and Globe offices in Dale Street, but it must again have been men of another race who provided the garish stained-glass window of St. George and the Dragon, which mars the interior of the great hall. This new race, with its love of ostentatious hygiene, no doubt, provided too the public convenience, which burrows under and weakens one corner of the great podium wall, on which as on an acropolis the magnificent south portico stands. No doubt they did this when they treated the finely-composed group to Nelson on the Exchange Flags in the same way. Indeed, that is what a public monument has almost come to signify. Even the Victoria Memorial, at the junction of Lord Street and Castle Street, has only missed such a foundation by a few feet, though in this case it cannot be said it would have mattered quite so much.

To the right of St. George's Hall, as you stand with your back to the railway station, is the strong, simple Doric column to Wellington, which it has been suggested should be repeated on the left hand side of the Hall if ever Liverpool requires a memorial to the late war—a safe proceeding at any rate—and behind that the fine range of the Law Courts, the Walker Art

Gallery, the magnificent rotunda of the Picton Library, equally impressive within, the Museum and the Technical School. This latter is obviously, with its absurdly blocked columns and bay windows, looking into the building instead of outwards, early twentieth century work, but its main lines agree with its neighbours and the whole makes a range of monumental building of which any town, even Edinburgh, might be proud, and, once possessing, attempt to keep clean by abating the smoke nuisance.

The other chief buildings of this period, when Liverpool excelled, are the great Customs House which closes the vista of South Castle Street with its very impressive dome,—a work of the Foster who refused to take St. George's Hall away from Elmes,—the Bank of England in Castle Street already mentioned, the fine Italian façade to the Palatine Club in Bold Street, and the charming little porticoed building for the Lyceum Club at the bottom of that street. The façade to the Athenæum in Church Street is of the same period and has some very delicate and charming detail in the upper stories which, as already suggested, may be contrasted with new twentieth century detail next door. The Wellington Rooms, with carved panels on either side of the entrance, by Gibson of tinted Venus fame, now renamed the Embassy Rooms, at the top of Mount Pleasant and become a public dancing rooms, and the Medical Association Building—the curved building on the opposite corner with a fine range of columns,—are of the same period; they, too, may be contrasted for elegance and restraint with the new block of Bacteriological Laboratories of the City and the University, which stands up between them at the top of the hill trying to face all ways with equal assertiveness.

This good tradition of reserved yet masculine classical architecture, which drew its inspiration as need be for the desired expression from Greece, Rome or Italy of the Renaissance, gave way before the romantic enthusiasm and religious excitability of the Gothic Revival.

It gave way, however, in Liverpool later than elsewhere, and Liverpool, too, thanks a little perhaps to the University School of Architecture, has been one of the first towns to recover from the debauch. Omitting therefore for the moment such good work in church building as the Gothic Revival brought about, and is its one dearly bought excuse, let us look at some of the quite recent buildings with which the classical revival of the last twenty years has endowed the town.

First there is the picturesque domed Dock Board Building at the Pier Head, built in the Palladian manner with the rotundity and unfluted columns of Wren and his followers. It is interesting to note how in this last architectural revival the buildings follow historical precedent, a hundred years of actual history being compressed into five of modern building. In this way we see the Cotton Exchange, five years later, still with picturesque towers maintaining the Wren tradition, but with a great screen of fluted columns between testifying to an appreciation of classical refinement, far enough away, however, from that of St. George's Hall. Another five years or so brings us to the Cunard Building and the West African Bank at the bottom of Water Street which correspond to the astylar buildings, like the Reform and Travellers' Clubs in Pall Mall, of Sir Charles Barry. This was the time when architects having fully digested, as they thought, Greek and Roman work turned to the Italian Palazzo for a model. What a good model it makes for a modern business structure the Cunard Building proves with its simple unbroken cliff-like walls. Though its skyline across the river may not compare to that of the Dock Board Building, nor even that of the absurd Liver Building on its other flank, its strength and success as a piece of street architecture is undoubted. Liverpool, however, never sinned so deliberately and stupidly, against all advice, as it did when having bought the Dock site on which these three buildings are erected, it allowed first the building with a big dome on a raised drum—symbol throughout western civilisation of a

building of first rate importance—to be placed out of the centre at one corner and then allowed the childishly gigantic and irregular Liver pile to outstrip it at the opposite. With this hopelessly unbalanced and indeed ridiculous collection of buildings as seen from the river for its conception of a gateway to Europe it almost deserved to lose, as it has done, the great Atlantic liners.

Coming right down to the present time when American influence is clearly shown in the latest buildings, we have as examples the Adelphi Hotel with its fine simple shape truthfully expressing its cellular steel construction, the tall commercial building opposite it, and those in and about Church Street. Of these the best are probably Crane's building, in Hanover Street and the Bon Marché, in Church Street. The new bank rising high above its neighbours in James Street, while American in its size and general shape, is unfortunately in the coarseness of its detail far below the American standard; witness the Greek fret, the size of a fence, which surrounds the building above the lower composition. However, on the whole, these recent commercial buildings in Liverpool, even the last, show an appreciation of suitable character which earlier ones like the Royal Insurance block did not. They do not pretend, with a vast array of columns, to be civic or municipal. They answer their programme in a direct and simple manner, and if their programme is to be tall and large and outstrip their neighbours that is not their architects' fault. Liverpool is being rebuilt in its commercial and shopping centres as London is, but with less ostentation and to a bigger scale. The Adelphi, it will be readily admitted, is a better building than any of the new ones in Regent Street, while Crane's Building, if in stone, would not disgrace Kingsway.

Turning at last to Church building all is overshadowed already by what has been accomplished in the new Cathedral by Giles Gilbert Scott. Not that there are not plenty of fine modern churches. Of such,

Liverpool has indeed more than its share. There are churches by Pugin in the slums, a fine church of Bodley's at Tue-Brook, St. Agnes, Ullet Road, by Pearson, where, under a hard brick exterior, hides a cathedral-like stone interior, completely vaulted, the beautiful group of church and priest's house, by Leonard Stokes, in Arundel Avenue, showing what an artist can do even with modern machine-made bricks, and last in point of time a lovely one at Old Swan by Gilbert Scott himself, in which the system of Romanesque vaulting from Provence has been applied with absolute success to a modern church. But the Cathedral, as is right, overpowers them all. It really looks as if Liverpool, which, until its recent revival here and in America had achieved the culmination of the classical movement in St. George's Hall, is to do the same in a new and romantic Gothic. For the Gothic of the new Cathedral is not the old Gothic of the stylists of the Gothic Revival, but something much stronger and more personal. The building is already a very impressive mass, especially as seen from the south-east at the corner of Hope Street and Upper Parliament Street, with the Chapter House and Lady Chapel in the foreground and their connecting corridor giving scale to the whole. Although only the chancel and the first transepts have yet been built, no one can doubt that the full cathedral effect is there. Given this romantic type of cathedral too few modern towns could have offered so suitably picturesque a site. The old graveyard in the quarry below makes a valley of the shadow of death, out of which, on its tree-clad cliff, rises the Cathedral, great already in height and in the strength of its lines. The interior of the Lady Chapel shows what richness of texture, yet what romance, apparent height and mystery, the architect has been able to obtain within its smaller limits. What he will achieve within the vastness of his great pile, when finished, strains the imagination to picture.

ENGINEERING DEVELOPMENT IN LIVERPOOL.

JOHN A. BRODIE, City Engineer.

ALTHOUGH a City and Port of so much commercial activity, Liverpool cannot lay claim to any great antiquity or historical events of note. It owes its success almost, if not entirely, to its unique geographical situation on the banks of the Mersey, and as forming the connecting link between the great industrial areas of Lancashire and the cotton and corn fields of America. Its growth has followed the expansion of its commerce. It has an area of 21,219 acres, with a frontage to the River of approximately $8\frac{1}{2}$ miles, extending inland a mean distance of four miles.

Two hundred years ago its population was about 10,000 and even 100 years ago the population was not more than 120,000. To-day (1923) it is 830,000. This figure, however, represents only the number of persons actually resident within the City boundary.

Notwithstanding this rapid growth, it is interesting to note that its population has considerably overflowed its boundaries both in a northerly direction and to the opposite side of the River. The three Boroughs which have thus been created—Birkenhead, Wallasey and Bootle—although separate from Liverpool as regards Local Government, may fairly be regarded as part of the parent city.

The bulk of their population is dependent on business carried on in Liverpool, and many thousands travel daily to and from its commercial centre.

Population.

The combined population of these districts at the present time (1923) is approximately as follows:—

Liverpool	830,000
Birkenhead	150,000
Wallasey	100,000
Bootle	80,000
Waterloo, Seaforth and other adjacent Districts	100,000
	1,260,000

This total of $1\frac{1}{4}$ million represents the Mersey community, the greater portion of which is embraced within a circle of three miles radius from the business part of the City.

Street System.

Liverpool, like other cities, has, until recent years, developed along the lines of least resistance and without much attempt to anticipate the possible requirements of the future. The old roads, however, when they are considered on a plan indicate a system of radial routes, somewhat irregular, but all converging to the one centre of business situated at the river side.

This old arrangement was much improved some 25 years ago and in many cases the streets were widened to make room for the double line electric tramways, which were then introduced.

A necessity arose for better cross-town communication, and Queens Drive was proposed and carried out with the object of enabling the ever increasing number of road vehicles to reach the north or south ends of the City without entering the already congested streets in the central area. It provides easier gradients and permits of more rapid travel and a consequent saving of time and money.

Queens Drive was laid out on the verge of the built-up area or as near thereto as circumstances would permit so as to pass through agricultural or undeveloped land.

It is 6½ miles in length and takes the form of a semi-circle of about three miles radius, with the City's commercial area as its centre.

The northern portion of this Drive is at present carrying two million tons of traffic per annum.

To provide for the increasing road traffic from the Docks to the manufacturing districts of Lancashire, and to give improved and quickened transport for inhabitants between their homes in the outskirts of the city and their business in the centre of the city, a complete system of main trunk roads, suitable for speeds of 20 miles per hour, has been devised and considerable lengths of these main roads have already been constructed through the areas still undeveloped or only partially developed within the City Boundaries. Each of these roads will ultimately have a number of tracks leading outwards so that the whole of the undeveloped areas may have quick and cheap access to and from the business centre.

The exceptional powers as to the provision of main roads which were granted to Liverpool in their Act of 1908 have been of great advantage, and the time has arrived when similar powers should be given to all authorities who are responsible for the provision of improved facilities to meet the requirements of future road traffic.

This short outline is, broadly speaking, the principle which has been adopted to meet future traffic requirements, and it is on these lines that Liverpool's arterial routes are being developed.

The width of road which the Corporation now regard as a minimum for main traffic routes and tramway service is 120 feet, and during the past 20 years about 25 miles of main roads of this width or over have been constructed or are in the course of construction. The cross section which has from experience proved to best

meet the requirements may be shortly described as follows:—

> The middle of the road is occupied by a double tramway track which requires a width of 29 feet. On each side of the tramway 25 ft. carriage-ways are provided, the remaining 20 ft. 6 ins. on each side is divided into footways 8 ft. wide on the outside, 10 ft. 6 ins. laid out as grass and trees, and the remaining 2 ft. as a narrow safety footway. The carriage-way can, when traffic requires additional room, be widened by reducing the width of the footwalk.

The climate in Liverpool is not generally regarded as ideal for tree growing in streets, but it has been found by experience that Planes, Ash, Elm and Sycamore thrive very well if carefully tended, especially as regards the preparation of the soil and in the size of the hole in which they are to be planted.

The Corporation has its own nursery where the young trees are grown and regularly transplanted and prepared for Boulevard planting, and when acclimatised a selection is made and transplanted to their permanent positions.

They are then well-grown trees, nine or ten years old, and, with but few exceptions, make good progress.

About 12,500 trees have been planted in wide streets, and in 50 years they should form handsome avenues.

Housing.

The Corporation is at present developing and laying out about 1,250 acres of land in various parts of the City under the Housing of the Working Classes Acts State-aided Scheme, and careful attention is being given in planning these areas to provide ample provision for the main traffic routes.

The intermediate areas between main routes are planned to suit local traffic requirements as distinct from through traffic. Such subsidiary roads being laid out so as to avoid as far as possible unnecessary junc-

tions with the main routes, which would impinge on the through traffic.

When the housing schemes are complete, about 12,000 houses will have been provided—out of this total about 4,600 have already been completed and occupied, and about 1,200 are in course of erection. In addition to these there are also occupied about 500 Army Huts which have been converted into Bungalows. Sites are provided for playing fields, allotments, schools, churches, shopping areas, public halls and other utility buildings.

Main Drainage.

The sewage of the City of Liverpool is mainly discharged into the tidal River Mersey by about twenty large outfalls, six to seven feet in diameter, situated at various points along its 8½ miles of frontage. There is, however, an area of about 4,318 acres, which, owing to its situation behind elevated ground, is drained on two Sewage Farms of about 200 acres each, where the sewage is treated on the Broad Irrigation System, supplemented by Bacterial Filters, the effluent eventually discharging into the River Alt and thence to the sea beyond the mouth of the Mersey.

This area during recent years has become developed and built up, and the farms are no longer capable of efficiently dealing with the sewage. To overcome this difficulty the Corporation has constructed an outfall sewer through the sandstone rock two miles in length, eight feet and nine feet internal diameter, and in parts 120 feet below the surface, which will shortly be put into service.

This will cut off the flow to the two farms and discharge into the Mersey at a point close to the Bootle boundary.

Railways.

Excellent main line railway access to Liverpool is provided by the lines terminating in Lime Street,

Exchange, Central and Birkenhead, by the Woodside Station, and access of a more purely local character is given by the Overhead Railway, and by the Mersey Railway Tunnel.

The Overhead, or elevated electric railway, opened in 1893, serves the line of Docks. Starting at the north at Seaforth, with a connection to the Southport line, it has a total length of $7\frac{1}{2}$ miles terminating at the Dingle Station at the south end, near the Herculaneum Dock. It is a separate company and not under the control of the Corporation.

It is constructed entirely of steel columns and girders, the normal span being 50 feet, with a few special spans of 98 feet. The floor or decking is formed of Hobson's arched plates 5/16 in. thick, on which the longitudinal sleepers (without ballast) are laid and keyed to flooring.

The Generating Station is at the Bramley-Moore Dock, about half way along the route. There are sixteen stations on the line. Special opening spans are provided to allow unusual loads or structures to pass into the Docks. These are, of course, only used after the railway traffic has ceased. Trains run in both directions at frequent intervals. Thirty years ago when the railway was constructed, the City's amenities did not receive the consideration which it does at the present time. The utility of the structure may be beyond question, but it can hardly be considered ornamental.

The Mersey Tunnel Railway.

In addition to the passenger ferry service, Liverpool is connected to Birkenhead by an electric railway under the Mersey mainly for passenger traffic, and operated by the Mersey Railway Company.

It forms a connection between the Central Station, Liverpool, and the Rock Ferry Station, where it joins the line to Chester. There is also a branch to Birken-

head Park Station where it connects with the line to Hoylake and West Kirby.

Its length is 5½ miles (double line) 4 ft. 8½ in. gauge.

A tunnel under the Mersey was first considered in 1827, but the works were not begun until 1879, when an experimental heading was driven under the river.

The permanent work was commenced in 1881, and the tunnel opened in 1889. It is 26 feet wide and 19 feet high from the rails, with gradiants of 1 in 30, and for a short length 1 in 27.

The two stations—James Street (Liverpool) and Hamilton Square (Birkenhead) are, respectively, 100 feet and 90 feet below the booking stall level, approached by hydraulic lifts, each capable of carrying 100 passengers.

Cross River Traffic.

The Corporation and adjoining Boroughs, in conjunction with the Mersey Dock Board, the Chamber of Commerce, and other commercial interests on both sides of the Mersey have under consideration the improvement of the facilities for Cross River Traffic.

The relative advantages and disadvantages of bridge or tunnel are now being weighed, and a report on the whole subject is in course of preparation. These schemes are not by any means new, as various proposals have from time to time during the past fifty or sixty years been brought forward by Engineers, none of which, however, have yet matured.

The vehicular traffic is at present conveyed across the river by goods ferry boats, especially constructed for the purpose. These should be seen in operation to understand the existing conditions. Up to a couple of years ago these boats were quite inadequate to cope with the number of vehicles, and long queues accumulated on both sides of the river waiting their turn to be taken across.

The Birkenhead and Wallasey Corporations, on whom the obligation rested, constructed new and more commodious boats which relieved the situation con-

siderably, but the time is not far distant when the traffic demands will be such that transit by water will be out of the question, and a tunnel or bridge will be imperative.

Whichever system may be ultimately adopted—and they have each their advocates—the advantages of having uninterrupted communication by day and night in all weathers can scarcely be over-estimated.

During the year 1922 the number of vehicles of all descriptions crossing the river amounted to 653,000, or roughly 2,000 per working day. The number of passengers crossing the river by ferries and tunnel is approximately 60,000,000 per annum.

THE ELECTRICAL UNDERTAKINGS OF THE LIVERPOOL CORPORATION.

H. Dickinson, M.Inst.C.E., M.I.M.E., M.I.E.E.,
City Electrical Engineer.

The Corporation of Liverpool purchased the business of the Liverpool Electric Supply Company in the year 1896, and of the Liverpool United Tramways and Omnibus Company in 1897.

As the result of these purchases it was decided that the supply of electrical energy for all purposes should be from joint Stations, and that the Plant should be of such a character as to be suitable both for Lighting and Traction. A direct current system of distribution at a pressure of from 460 to 550 volts was therefore adopted.

At the date of the purchase of the undertakings by the Corporation, the supply of electrical energy was furnished from four Generating Stations, situated respectively at Highfield Street, Paradise Street, Oldham Place, and Lark Lane.

These Stations were equipped with Lancashire Boilers and direct current Dynamos, coupled to Willans High-speed Engines.

To meet the rapidly-increasing demand, it was decided to build at once larger Stations.

Two large stations were accordingly erected, one at Pumpfields and one at Lister Drive. In the latter case a site was acquired capable of considerable development.

Both these stations were laid out on the same general lines, and building operations commenced in 1899 and 1900.

The desirability of concentrating the generation of electricity was gradually developed, and step by step all the older stations were converted into sub-stations

and the generation of electrical energy was confined to Lister Drive.

In the development of this process a new station was erected at Lister Drive, called Lister Drive No. 2 to distinguish it from the original station.

This station was commenced in 1904 (the building which is adjacent to and generally similar in design to No. 1 Station) was equipped with four 2,000 kilowatts British Westinghouse Horizontal Turbo Alternators, and six 2,000 kilowatts Curtis British Thomson Houston Vertical Turbo Alternators.

The Boiler-houses contain 16 Babcock and Wilcox water tube boilers, each capable of evaporating 25,000 lbs. of water under ordinary working conditions and each having a total heating surface of 6,182 square feet.

The boilers work at a pressure of 200 lbs. per square inch and are fitted with chain grate stokers and superheaters capable of giving a superheat of 200° Fahrenheit.

Each bank of four boilers is connected to an economiser of Messrs. Green's standard make, containing 544 tubes.

The total output of this Station when completed was 20,000 kilowatts.

In 1911 it was decided to reconstruct the plant in No. 1 Station as the buildings were capable of accommodating a much larger capacity of plant mainly owing to the advent of the steam turbine.

With this end in view the whole of the original plant in the No. 1 Station was gradually reconstructed.

The following is a description of this Station immediately after the completion of this reconstruction :—

The generating plant comprises one 10,000 kilowatt British Westinghouse Turbo Alternator, two 6,000 kilowatt British Thomson Houston Turbo Alternators, two 3,500 kilowatt British Thomson Houston Turbo Alternators, and two 2,000 kilowatt British Westinghouse Direct Current Turbo Generators. The total

output having been raised from 8,400 kilowatts to 33,000 kilowatts.

The condensers for these sets are of the surface type and the air pumps are for the most part of the ejector type.

A Lea recorder is provided for each, which measures the amount of condensate extracted from the condenser.

As Lister Drive is some distance from the River, Cooling Towers had to be used for cooling the circulating water for the condensers.

The Boiler-houses contain 24 Babcock and Wilcox water tube boilers each capable of evaporating 25,000 lbs. of water per hour under ordinary working conditions, each having a total heating surface of 6,182 square feet.

The boilers work at a pressure of 200 lbs. per square inch and are fitted with chain grate stokers and superheaters capable of giving a superheat of 200° Fahrenheit.

Above the boilers, supported on heavy steel stanchions and girders, is an economiser floor; each boiler is connected by a special uptake flue to an economiser of Messrs. Green's standard make, containing 192 tubes each 11 feet 6 inches long.

Sidings from the London, Midland and Scottish Rly. run alongside each boiler-house and the coal is delivered from trucks. Each truck is, in turn, shunted over two hydraulic rams, one under each axle, the coal is tilted into a hopper constructed below the rails and from this it is discharged into an endless bucket conveyor and elevator by which it is raised to the coal hoppers above the boilers.

The ashes from the boilers are dumped to a floor below the firing level, and from thence discharged direct through an ash-chute on to a chain conveyor which runs immediately below this floor. They are then elevated to a ferro-concrete ash storage hopper outside the Station, from which they are discharged into railway wagons or carts for removal.

With the alteration carried out the steam-raising capacity has been increased to three times what it was originally.

In 1919, in order to meet the increasing demand for electrical energy, it was found necessary to reconstruct the plant in the No. 2 Station, and it was decided to take out the four 2,000 kilowatts British Westinghouse Sets and instal two 12,500 kilowatts Metropolitan Vickers Turbo Alternators with 25% overload for two hours on a ·8 power factor.

These machines generate 3 phase alternating current at a pressure of 6,600 volts at a frequency of 50 periods per second when running at a speed of 3,000 revolutions per minute.

When the first of these machines was started up it was the only machine of this size in the world running at 3,000 revolutions per minute.

For cooling the Generator a closed system has been adopted, the air being forced by means of a fan through the alternator and thence through a cooler consisting of a large number of tubes through which cold water is passed, the air thus being cooled is again circulated through the alternator. This system does away with the necessity for filtering the air and eliminates any possibility of fire on account of the limited amount of air available for supporting combustion.

Each turbine is fitted with a 23,500 square feet surface condenser. The circulating pumps are capable of passing 16,200 gallons per minute through each condenser and are driven by motors in duplicate through clutches. The motors being placed one at each end of pump shaft. The air is extracted from each condenser by two Steam Ejectors each capable of dealing with 60% of the normal load.

The condensate is pumped from the condensers through a Lea Recorder and thence passes through a feed water heater to the hotwell tanks.

Each Station is fitted with a 65 ton overhead travelling crane.

A large 460 volt storage battery capable of giving a discharge of 1,000 amps. for one hour is placed in a room adjoining the Switch House, to be used in cases of emergency for auxiliary plant and station lighting.

The total output of this Station, after reconstruction, is 37,000 kilowatts, and the combined output of Nos. 1 and 2 Stations after reconstruction is 70,000 kilowatts, in place of the original combined capacity of 28,400 kilowatts.

Switchboards and Sub-Stations.—The Low Tension output from No. 1 Station is dealt with by two switchboards running its full width, one board controlling the lighting supply the second the traction supply. These boards are equipped with the usual measuring instruments and protective gear, *i.e.*, fuses on lighting and circuit breakers on traction.

The lighting board is divided into two sections which are coupled by circuit breakers. One section has coupled to it the D.C. generating plant and all the outgoing feeders. The other section has coupled to it the battery previously mentioned, either direct or through a reversible booster, and also all the D.C. auxiliary plant. In case of emergency the coupling breakers are opened, leaving the battery on the auxiliary plant and station lighting only.

The High Tension output is controlled by a cellular type switchboard consisting of 54 cubicles situated on an upper floor running across Nos. 1 and 2 Stations. The total length of this board is 245 feet. The control board is situated in No. 2 Station for the whole of the High Tension plants.

The Switch-room is divided into four sections, which are usually coupled, but which can be separated at will.

For the control of the two 12,500 kilowatts Turbo Alternators and works transformers a new switch-room has been built on the roof of the Station immediately above the switch-room mentioned. The busbars from this new section have a capacity of 3,000 amperes and

can be coupled by selector switches to either or both of the four sections in the room below.

The outgoing feeders from the four sections number 29, and each leads to a corresponding section at a sub-station. In some cases four feeders, one from each section are coupled to four sections entirely isolated in a sub-station, thus giving four isolated sources of supply. These sections in the sub-stations can be coupled. This gives a very safe and at the same time flexible system.

Three phase high tension distributing mains are run in multiple to converting Stations situated at Pumpfields, Highfield Street, Paradise Street, Oldham Place, Fairclough Lane, Beaumaris Street, Lodge Lane, Lavrock Bank, Cobb's Quarry, Rice Lane, Smithdown Road, Garston, Lark Lane, Gateacre, Walton, Aigburth Vale, and Waterloo.

To utilise the waste heat from the Corporation Refuse Destructors at Lavrock Bank, Smithdown Road, Cobb's Quarry, Charters Street and Garston, steam-driven generating plant of the high speed direct coupled type has been erected and direct current is generated and fed on to the low tension network.

Rotary Converter Automatic Stations, connected to the lighting network have been installed. The starting up is carried out by a series of relays which first connect the plant to the High Tension system, and then step by step in their respective order the relays operate and finally put the D.C. pressure on to the outgoing feeders.

Distribution.—The underground distributing mains are, for the most part, laid in the Callender solid system, the cable being first insulated with vulcanised bitumen, and then laid in iron troughs in which they are supported on wooden bridges. The troughs are filled in with bitumen and covered over with a layer of concrete. The cables have been more recently laid in earthenware troughs with porcelain bridges and covered with earthenware tiles.

The joint boxes fixed beneath the pavement are filled in with heavy insulating oil.

The feeding mains on the three wire system, with 460 volts between the outers are terminated in boxes above the ground level, which contain disconnecting switches and fuses, controlling the distributing mains which have their origin in these boxes.

During recent years a considerable amount of paper insulated lead sheathed and steel armoured cable has been put down, which is laid in earthenware troughs filled in with pitch.

The alternating current supply given through these cables is at a pressure of 400 volts 3 phase 50 cycles per second, power being supplied at 400 volts 3 phase and lighting at 230 volts between phase and neutral. This system is being rapidly developed, and especially in the outer districts of area where the existing network of mains is becoming loaded. The supply from the direct current cables for lighting and power is available throughout the City at a pressure of 230 or 460 volts, the supply for motors over 6 h.p. being for the most part given at the higher pressure from the outers of the three wire network.

The 3 phase High Tension 6,000 volt mains, connecting the Lister Drive Power Station with the various sub-stations consist of specially paper-insulated, lead-covered, and armoured cables laid in troughs filled in with either bitumen or pitch. There are approximately 150 miles of High Tension cable laid down in the area.

Three phase High Tension mains suitable for a pressure of 33,000 volts have recently been laid down in order to deal with the increasing load at the Northern and Southern ends of the area of supply, and consist of impregnated, paper-insulated, lead-sheathed and wire-armoured cables which are direct in the ground and protected from damage by placing in position over the cables a prepared concrete slab bearing the word 'ELECTRICITY' branded in the slab.

During the last year, approximately sixty miles of

trench has been opened in the supply area in order to lay down new feeders and distributors which have become necessary to deal with the ever-increasing demand for electric supply in the City.

The number of units sold during the past three years has been as follows:—

	Lighting & Power.	Traction.	Total.
1920 ...	56,508,410 ...	29,825,100 ...	86,333,510
1921 ...	61,775,150 ...	26,413,265 ...	88,188,415
1922 ...	71,785,286 ...	29,605,983 ...	101,391,269

The Capital Expenditure of the Electric Supply Undertaking up to the 31st December, 1921 was £3,092,134.

The total income for the year 1921 was £995,988.

The total connections to the supply mains excluding the Tramways are equivalent to 82,951 kilowatts and the Horse Power of motors connected 67,957 and the number of consumers 24,716.

Street Lighting.—The number of public lamps in the City for street light purposes is approximately 20,824, and the annual maintenance charges amount to approximately £97,000.

Most of the public lighting is done by gas lamps fitted with one or two incandescent burners, the inverted type being now favoured. 496 miles of road are lighted by this system, but electricity is now making rapid progress, and about 30 miles of road are electrically lighted by means of approximately 2,000 lamps of various types. These will be continually added to, as in all the new main roads in the City, and those on the new Housing Estates, electric lamps are being fixed. In important thoroughfares, high-power gas-filled incandescent lamps are replacing the old arc lamps, but in ordinary streets incandescent vacuum lamps of nominal 50 candle-power, fixed at an average distance of 54 yards, are used.

LIVERPOOL CORPORATION TRAMWAYS.

P. Priestly, A.M.I.E.E., M.I.A.E.,
General Manager.

The Liverpool Corporation commenced to operate the Tramways System, which they purchased from the Liverpool United Tramways and Omnibus Company, in 1897. The Corporation decided to electrify the horse system, and adopted the overhead trolley system of traction, the first section being opened in November, 1898.

The total length of tramway track at present operated is 133 miles, and travelling facilities are provided not only for the Liverpool inhabitants, but for those of the adjoining Boroughs of Bootle, Litherland, and Prescot.

The Liverpool Tramways System joins up, at Prescot, with the St. Helens and South Lancashire Tramways System, the latter of which forms a connecting link between Liverpool and Manchester. Passengers can travel from Liverpool by various tramcar and motor omnibus systems as far as Halifax, Bradford, Leeds, etc.—a distance of near 90 miles.

The Great Crosby Tramways—which serve Crosby, Waterloo and Blundellsands—meet the Liverpool cars at Seaforth.

The majority of the routes on the Liverpool System radiate in fan-like fashion from a central point at the Pier Head, where they are run in conjunction with the Ferry-boat Services from Rock Ferry, Birkenhead, Seacombe, Egremont, and New Brighton. In addition passengers proceeding to and from the liners—which start for all parts of the world from the Princes Landing Stage—as well as pleasure seekers proceeding to the Isle of Man, North Wales, or the Irish resorts, find the

Tramways a ready means of travelling between the Liverpool Suburbs, the different Railway Stations, and the Stage.

The Tramways Terminus at the Pier Head is unique, providing facilities for dealing with a vast number of cars operating on no less than 27 different routes. 4,000 cars are dealt with each weekday at this terminus, and during the crush hours on Bank Holidays, Saturdays, etc., no less a number than 300 cars per hour—carrying nearly 20,000 people, enter and leave the Pier Head. This enormous traffic is dealt with by the tramway track being divided into loops. During normal times, six loops are in use, the tramcars proceeding from the south and south-east portions of the City use one section, from the east portion another section, and from the north a third section. In case of a breakdown or dislocation of traffic, the lines are laid in such a manner that no less than ten loops are available for classifying the cars on the different routes, and placing them in their proper order, and to their scheduled times. The radial routes are intersected at the principal traffic points by cross-city routes, thus affording access from north and south at varying distances from the centre of the City.

The record number of passengers carried on the Liverpool Tramways System in any one year was 220,219,091, equivalent to the whole of the population of the districts served by the Tramways being carried 220 times per annum.

Motor Omnibus Services are also run to link up the outlying districts, and to serve as feeders to the Tramways System.

Rolling Stock.

The Corporation build and maintain the whole of their Tramways rolling stock, which comprises 630 cars and 23 motor omnibuses, as well as the usual complement of depot and stores vans, motor tower wagons, jack wagons, salt wagons, etc.

The standard electric cars are of the single truck,

double-deck type, with wheel base ranging from 7 feet 6 inches to 9 feet, and they provide seating accommodation for 22 inside, and 42 on the upper deck. Nine passengers are allowed to stand inside. The cars are fitted with two 40 h.p. traction motors, and the latest type is equipped with roller bearings. The rolling stock is housed in nine car sheds, situated in the various suburbs.

Building and Repair Works.

The building and repair works are situated at the north end of the City, and cover an area of 14,208 square yards. The whole of the work in connection with the building, maintenance, and renewals of the rolling stock is carried out at these works, the carsheds only being utilised for housing, cleaning, and examining the cars, etc. The Works are well equipped with up-to-date machinery, and contain a general stores, a wood-working machine shop, and fitting shop, with smithy, pattern-makers' shop, brass foundry, etc. In addition, there is an armature and controller room, and a main car repair shop, which has accommodation for 77 cars on seven tracks.

Owing to the extension of the system, and increase in the number of cars required, it was found necessary to have additional accommodation at the Works, and the painting and varnishing shops were, therefore, removed to Wavertree Depot until such times as the new car building and repair works at Edge Lane are completed.

Permanent Way.

The whole of the Tramways permanent way was constructed and is maintained by the Corporation. The rails are of the grooved girder section, and those at present in use are of a heavy type, weighing 135 lbs. per yard. They are laid on a foundation of Portland cement concrete. In certain districts where the width of the roadway allows, the track is laid on sleepers

as in the ordinary railway and the intervening spaces filled in with crushed clinker and finished with a coating of loam or earth and grass sown. The track is enclosed by a low hedge on each side outside which is a kerb close enough to the hedge to keep vehicles off, but not sufficiently wide to accommodate pedestrians.

Stopping places are selected at about ¼ mile intervals or at the intersections of main streets.

This system of grass tramway tracks has the advantage of cheaper first cost and the elimination of noise and dust. In addition, fast services—with speeds averaging about 20 miles per hour—can be maintained without fear of accidents as the track is reserved for the use of tramcars only.

It is being adopted in Liverpool on all main arterial roads in the outskirts and up to the present about 17 miles have been or are in course of being constructed.

The cost to the Tramway Authority of laying sleepers, fencing and grassing is about 50 per cent. less than paving with setts on a concrete foundation.

Overhead Construction.

The overhead equipment is also maintained by the Tramways Department, and embraces the usual types of construction, viz., centre poles, span wires with poles and rosettes, and side bracket arms. The overhead conductors are mainly .409 inches diameter, and the chief junctions are equipped with automatic controllers. A large number of the routes are circular, but wherever it is necessary to have dead-end termini, a special arrangement of the overhead construction enables the trolleys to be reversed, without leaving the wires, thus preventing the necessity of the cars being left in darkness when the conductor is changing the trolley from one line to another for the return journey. This avoids the danger of other vehicles colliding with the darkened cars and of accidents to passengers boarding or leaving them.

Queues and Shelters.

A system of queues has been introduced where necessary in different parts of the City, and Shelters provided at the main collecting points in the City.

Fares.

The Corporation, in considering the question of fares, recognised that owing to the districts up to three miles from the centre of the City not having sufficient vacant space to allow for the building of the necessary houses required to meet the demand, and that, in consequence, houses, even for the working-class population, would have to be built some considerable distance from the business area, decided to give a cheap fare for through passengers, and distances up to $6\frac{1}{4}$ miles can be travelled on the cars for 3d. The 2d. fare allows an average distance of $2\frac{1}{4}$ miles to be travelled, with shorter distances for 1d. fares.

School children can ride for half fares, and blind persons and ex-service men suffering from leg disabilities consequent upon war service are carried free.

The Tramways Department of the Corporation also print the whole of the tickets used on the system, and it is interesting to note that about 100 tons of paper are required for this purpose per annum.

The Corporation also make their own punches, uniforms, bags, belts, etc.

Current.

The electric current is obtained from the Electric Supply Department, the Corporation main generating station being situated at Lister Drive, where two 12,500 kilowatts Metropolitan Vickers Turbo Alternators were recently installed, which machines generate a three phase alternating current at a pressure of 6,600 volts, which is afterwards converted to direct current, and is supplied to the Tramways at 500 volts pressure. The current is delivered by a special network of mains to feeder boxes adjacent to the various Tramway routes.

Financial.

The Capital Expenditure on the Tramways System is £2,375,802.

Since the inauguration of the Undertaking £1,750,000 has been provided for liquidation of the Sinking Fund, £1,125,000 has been paid in rates and taxes, whilst £1,062,899 has been contributed towards the relief of the City Rates. In addition £1,400,000 has been spent on renewal of permanent way, rolling stock, etc.

THE LIVERPOOL CORPORATION WATERWORKS.

J. R. Davidson, Water Engineer.

Historical.

The public water supply of Liverpool dates back to the reign of Queen Anne when, in 1709, Parliament sanctioned a scheme to bring water into the Town from Bootle.

In 1799, the Bootle Company was formed and works were constructed for bringing water into the Town from springs on land belonging to the Earl of Derby. This was followed by the formation of the Harrington Company in 1822, the supply being obtained from wells sunk in the new red sandstone in and adjacent to the Town.

In 1847, the Corporation acquired both these undertakings by purchase, and also took over the Green Lane Works from the Highway Commissioners.

Sources of Supply.

The present sources of supply are—

1.—*Wells.*

The existing wells are within the City, and geologically are all in the pebble beds of the new red sandstone formation.

Situation.	Constructed.	No. of shafts.	Depth. Feet.	Further depth of bore holes. Feet.	Yield gallons per day. (Normal)
Green Lane	1843	4	185	310	1,330,000
Windsor (Lodge Lane)	1846	2	210	380	1,000,000
Dudlow Lane (Wavertree)	1870	2	247	300	1,140,000

2.—*Rivington Gravitation Scheme.*

General.

The first gravitation scheme for the supply of water to Liverpool was prepared by the late Mr. Thomas Hawksley, and comprised the construction of large impounding reservoirs on the upper waters of the Rivers Douglas and Roddlesworth, in Lancashire.

The works were authorised by Parliament in 1847, and construction was commenced in 1852, water being first delivered into Liverpool in 1857. Additional reservoirs, known as the Upper Roddlesworth and Yarrow Reservoirs were constructed in 1865 and 1875, respectively.

Previous to 1902, the Corporation had acquired, by private purchase, a considerable portion of the Catchment Area at the Northern end of the works, and in that year an Act was obtained for the compulsory purchase of the remainder of the watershed.

Watershed and Reservoirs.

The Rivington Watershed comprises 9,668 acres of thinly inhabited hill and moorland on the Millstone Grit Formation lying between the towns of Bolton and Blackburn, in Lancashire. The elevation ranges from about 450 feet O.D. in the valleys, to 1,500 feet on the hill tops.

The table, page 81, gives the area and contents of each reservoir, and the principal dimensions of the embankments.

The reservoirs contain, when full, 4,105,000,000 gallons. Their total surface area at the overflow level is 598 acres, and their total length, measured along the top water lines, is 5½ miles. The total length of the embankments is over 3 miles.

Name of Reservoir.	Area in acres.	Contents in million gallons.	Embankments. Length. Feet.	Greatest depth in feet.	Width of the Bye Washes. Feet.	Height of Top water above Sea Level.
Roddlesworth (Upper)..	26·0	178	1,190	69	69	615.3
,, (Lower)..	16·4	99.7	590	81	98	545·13
Rake Brook ..	13·8	79·9	1,500	84		545·13
Anglezarke ..	191·6	1,019	3,550	46	105	465·63
Chorley	10·1	48·3	990	39	20	533·51
Rivington (Upper and Lower)	275·0	1,841	6,280	61	222	423·23
Yarrow	65·0	839·2	2,894	103	100	558·63
Filter Beds (8 in number)..	5·82	—	—	—	—	378·85
TOTALS..	603·72	4,105·1	16,994			

Filtration.

The water is filtered at Horwich where there are eight slow sand filters, having a total area of 28,230 square yards, and two Clear Water Tanks, each six million gallons capacity.

Water is carried from Horwich to the Service Reservoirs at Prescot by a 44 in. Cast Iron main, 17½ miles in length.

3.—*Vyrnwy Gravitation Scheme.*

The Vyrnwy works were authorised by Parliament in 1880, the Engineers being the late Messrs. Thomas Hawksley and George Frederick Deacon. The scheme provided for the collection of water in a large reservoir in Montgomeryshire on the upper waters of the River Vyrnwy, a tributary of the River Severn.

Water is impounded by a large masonry Dam which closes the mouth of a broad flat valley, supposed to

have been the site of a post-glacial lake basin in the Silurian rocks.

The catchment area has been increased by the construction of tunnels which divert into the Lake water from two tributary streams which originally joined the River Vyrnwy below the Dam.

The aqueduct will eventually consist of four lines of pipes, of which two have already been constructed. The first main was completed and water brought from Vyrnwy into Liverpool in 1891.

The growing demands of the City necessitated the laying of a second main in 1905, and this is now being drawn upon to its full capacity.

Each of the existing mains consists of Cast Iron pipes, 42 in. diameter, with a present total capacity of 28 million gallons per day. The Aqueduct is divided into six sections by Balancing or Break Pressure reservoirs at suitable points on its length of 68 miles between Vyrnwy and the service reservoirs at Prescot.

The water is filtered at Oswestry where there are 12 slow sand filters, having a combined area of 10 acres. Three additional beds are now under construction.

The whole of the Catchment Area has been acquired, and the Corporation has gradually taken into hand most of the farms formerly let to tenants.

The hill lands are utilised for sporting and the grazing of sheep, the Corporation flock numbering over 13,000, while the slopes immediately surrounding the Lake are being taken in hand for afforestation purposes.

Previous to 1912, 875 acres, chiefly on the south-west side of the Lake had been planted. In that year an agreement was entered into with the Treasury to plant in partnership a further 4,000 acres in a period of 20 years. The War interfered with progress of this scheme, but already 1,290 acres have been planted. The species of trees which have given best results are Douglas Fir, Common and Sitka Spruce, European and Japanese Larch; whilst other varieties planted include Corsican Pine, Silver Fir, Weymouth Pine and Beech.

BOOTLE.

J. Spencer Tumilty,
Town Clerk.

The Borough was incorporated by Royal Charter on 30th December, 1868, and was constituted a County Borough in 1888 by the Local Government (England and Wales) Act, 1888, and a Parliamentary Borough under the Representation of the People Act, 1918. Major James Burnie, M.C., is the present Member, the total number of electors being 34,428. The population at the Census of 1921 was 76,508, rateable value £591,326, and area 2,346 acres. The Parishes of Bootle and Linacre in the Borough are mentioned in Doomsday Book.

The Town Council consists of 44 members, composed of 11 Aldermen and 33 Councillors, and the Borough is divided into six wards, and for Poor Law purposes is part of the West Derby Union. The Council under various Acts of Parliament appoints its representatives on the Lancashire Asylums Board, the Lancashire County Rate Committee, the Lancashire Inebriates Acts Board, the Lancashire and Western Sea Fisheries Committee, Liverpool Water Committee, Liverpool Port Sanitary and Hospitals Committee, Liverpool University Court, the Coroners' Joint Committee, the West Lancashire Territorial Army Association, and the Assessment Committee of the West Derby Union

The Borough adjoins the City of Liverpool and is supplied with water and electricity by the City and with gas by the Liverpool Gas Company.

The Municipal Buildings consist of a Town Hall and Municipal Offices combined, with an adjoining Free Library and Museum, Police Station and Police Court, Public Baths and Gymnasium. Its other services

consist of a Fire Station with firemen's dwellings, a Public Park (the gift of the Earl of Derby, Lord of the Manor) and Recreation Grounds, Infectious Diseases Hospital and Sanatoria, Cemetery, a Technical School and Secondary Schools for Boys and Girls, respectively.

There are large Docks within the Borough belonging to the Mersey Docks and Harbour Board, which are a continuation of the dock system in the adjoining City, the water area of the Bootle Docks being nearly 116 acres with a quayage of six miles. There are extensive ship-repairing works, engineering works tanneries, foundries, wire rope works, tin box manufacturers, tin smelting works, dye works and electrical works, together with many warehouses used for the storage of cotton, grain and other goods. There are flour mills and large timber yards, the timber trade of the Port being mainly concentrated in the Borough.

There is a convenient tramway service in the Borough which is worked by the Liverpool Corporation, the lines being leased to the Liverpool Corporation by the Bootle Corporation.

Free Public Libraries and Museum.—Established in 1887, the Public Library and Museum have contributed materially to the intellectual advancement of the community. In the basement rooms was founded the Technical School, which in 1900 was transferred to a new and more suitable building situate in Balliol Road.

The Library embarked upon its career in February, 1888, with a collection of 4,808 volumes, but this total has since risen to 31,349 volumes. The Lending and Reference departments are particularly rich in biographical, historical, and scientific works, and considerable use is made of them by the various educational agencies operative in the Borough, as well as by the general reader. For the year ended the 31st March last nearly 159,000 issues were recorded. A noteworthy feature of the work of the institution, and one which has been favourably commented upon by

eminent educationists, is the Book Delivery System which was introduced in 1894. Under it every school in the Borough is linked with the Central Library, and the issue of books for the twelve months last computed amounted to upwards of 46,000. Another special feature which calls for mention is the Teacher's Ticket, whereby the holder is entitled to the use of four books for a month at a time. One hundred and fifteen teachers are at present availing themselves of this facility.

The Reading Rooms are extensively patronised, the latest recorded attendance thereat having been estimated at upwards of 158,000. A liberal supply of excellent journals and magazines of great variety of point of view and interest is provided.

The Museum was at first (1887) one of rocks, fossils, minerals, birds, beetles and shells, and hardly anything else. These were purchased from the Royal Institution of Liverpool. Now mammals, reptiles, amphibians, fishes, insects, crustaceans, and lower forms are represented. Many rare specimens are included, *e.g.*, a *Drepanis*, some scarce parrots, a Sandwich Island goose, a fine lot of footprint impressions from Cheshire and Hessberg sandstones, one of them being apparently the type from which Sir Richard Owen figured one of the Ichnites in his *Palaeontology*, 1861. A large cabinet of European beetles with a notebook, written in French, on the aberrant forms all carefully numbered and referenced, is one of the treasures of the Museum, and would well repay the attention of a coleopterist. Specimens are freely lent for teaching purposes.

The principal part of the exhibits in the Art Room consists of objects generously lent by the Authorities of the Victoria and Albert Museum, but these are supplemented by frequent loan exhibitions obtained from national and other sources. 44,860 visits were paid to the Museum during the past year.

A Branch Library and Reading Rooms were established in 1902, and are largely frequented by the

residents of a thickly populated industrial area. The Lending Library comprises nearly 4,000 volumes of an interesting and diversified character. 30,060 issues of books were registered during the year lately terminated, whilst the estimated attendance at the Reading Rooms, which are well supplied with periodical literature, exceeded 200,000.

Cemetery.—The Council act as the Burial Authority under the Public Health (Interments) Act, 1879, the Burial Act, 1900, and Acts incorporated therewith. The Cemetery was opened in 1911, the area of land comprising $31\frac{3}{4}$ acres, and is situate in Linacre Lane, and portions are allocated for Church of England, Nonconformist and Roman Catholic interments. A portion of the land is at present used as allotment gardens.

Housing.—The Corporation acquired two sites in Orrell for their Housing Scheme for the erection thereon of about 900 houses, and have erected 302 houses on one site, which is admirably suited for the purpose, adjoining Ford Station on the electric railway.

Borough Police.—The Borough Police Force was established on 1st July, 1887, and is composed at present of a Chief Constable, Chief Inspector, 4 Inspectors, 13 Sergeants, and 81 Constables, the total authorised strength being 100.

Fire Brigade.—The Brigade was reorganised in 1886 and the staff at present consists of a Chief Officer, a Second Officer, 3 Engineers and 27 Firemen. The Brigade undertakes the duty of the extinguishment of fires in the adjoining Urban District of Litherland, under arrangements with the Council of that District. An efficient service of street fire alarms has been established, and the appliances include two petrol motor fire engines and escapes combined, one steam motor fire engine, and one steam fire engine.

HEALTH SERVICES.—The Public Health Department administers a comprehensive and well-organised scheme of work, including the following activities:—

(*a*) General sanitary supervision, including routine sanitary inspection, supervision of food supplies, and housing inspection carried out by a staff of a Chief Sanitary Inspector and three qualified Assistants.

(*b*) Isolation Hospital. Notifiable infectious diseases are treated in the Corporation Isolation Hospital, Linacre Lane, with a resident Medical Officer and Nursing Staff of 15, and providing 98 beds.

(*c*) The Anti-Tuberculosis Scheme comprises a Tuberculosis Dispensary at which the Tuberculosis Officer attends daily; two whole-time Nurses as Tuberculosis Visitors; a Sanatorium at Maghull (7 miles distant), accommodating 20 early cases of pulmonary tuberculosis; financial agreements with certain voluntary hospitals for the treatment of non-pulmonary tuberculosis; and a newly-erected pavilion of 28 beds at the Corporation Hospital, Linacre Lane, for the reception of cases of established pulmonary tuberculosis.

(*d*) The Venereal Diseases Scheme consists of a Treatment Centre (with 8 sessions weekly) established at the Bootle Borough Hospital.

(*e*) The Maternity and Child Welfare services are especially complete and efficient, and include a staff of five Health Visitors, the maintenance of three Infant Consultation Centres and two ante-natal Consultation Centres meeting each week, and a newly-opened Maternity Home of 10 beds.

(*f*) The School Medical Service is administered by the Medical Officer of Health, and has for executive staff one whole-time and three part-time Medical Officers, with a Dental Surgeon and three School Nurses. A well-equipped and largely-attended

Treatment Clinic is provided in the School Medical Offices.

The total estimated cost of the above Health Services for the financial year 1923-1924 is £19,090, representing, after the deduction of receipts in aid, a rate of 8·97d. in the £.

During the year 1922 the total number of births was 2,051, equal to a birth-rate of 25·7 per 1,000 of the population. In the same period the deaths totalled 1,093, equal to a rate of 13·7 per 1,000. Of these deaths 164 were of infants under one year of age, which is equal to 80 deaths of infants to every 1,000 births.

Public Baths and Gymnasium.—The Public Baths in Balliol Road were opened in 1888 and consist of a Gentlemen's Swimming Bath, 100 feet by 30 feet, and a Ladies' Swimming Bath, 60 feet by 25 feet. There are private Slipper Baths supplied, and a Roman Hot-Air and Vapour Bath. The Corporation have also provided an Open-air Swimming Bath and Slipper Baths in another part of the Borough (Marsh Lane). All the Baths are supplied with salt water from the Docks, by arrangement with the Mersey Docks and Harbour Board. The Gentlemen's Swimming Bath is converted into a Gymnasium in the winter months.

Collection of House Refuse.—The collection is made by electrically-driven motor vehicles. Ashbins are emptied weekly and ashpits monthly, with the exception of the more crowded districts, in which case they are emptied every 10 days during the summer months. The refuse is conveyed to a destructor and all destroyed.

Public Park and Recreation Grounds.—The Derby Park in Oxford Road is situated in the most elevated and healthy part of the town, and the site of which, as already mentioned, was the gift of the Earl of Derby. It has been ornamentally laid out and provided with a lake, which is extensively used for yachting. Bowling

greens and tennis courts are also provided and greatly patronised by the public. There are also six recreation grounds situate in various parts, and the Corporation have sub-leased a portion of the South Recreation Ground to the Bootle Cricket Club on condition that the ground is open free to the public during matches.

BIRKENHEAD.

J. Fearnley, Town Clerk.

The County Borough of Birkenhead is situate in the County of Chester on land rising from the bank of the River Mersey westwards through the old Townships of Birkenhead and Claughton-cum-Grange to Oxton, which, with a portion of Bidston on the immediate outskirts of the Borough, extends along a high ridge running roughly east and west, averaging over 200 feet above sea level and commanding a view of the river. The Borough returns two Members to Parliament and has a separate Commission of the Peace and Court of Quarter Sessions. The area of the Borough is 3,850 acres, with 150,000 inhabitants, and a rateable value of £861,869.

The Township of Birkenhead is of ancient origin, though its rise to importance took place wholly in the nineteenth century when it developed with great rapidity. The defined history of the Township dates practically from the foundation, in about the year 1153, of a Priory of sixteen monks of the Benedictine Order, on a part of the original Barony of Dunham, in Cheshire. The Priory was situated upon the banks of the River Mersey, and in 1332 a right of ferry was by Letters Patent confirmed to the Priory by King Edward III.

The Borough forms part of the Port of Liverpool, has very extensive Docks, and shares in the general import and export trade of the Port. Among other important shipping lines using the Birkenhead Docks are the Holt Line, the Clan Line, the Bibby Line, the Anchor Line, and the Hall Line, trading to all parts of the world. It has large and important industries,

and with its livestock trade and lairages, accommodating 6,600 cattle and 22,000 sheep, it can justly claim to be the meat market of the Empire. As a centre, with the adjoining Borough of Wallasey, of the milling trade it is the largest in Europe, and is eclipsed only by Minneapolis in the whole world. While the yards of Messrs. Cammell, Laird and Co., Ltd., famous as the cradle of mercantile and naval vessels of the very largest kind, make it one of the most important of shipbuilding centres.

The project for the construction of the Docks originated in or about the year 1825 with the late John Laird, M.P., who, at the same time, was initiating the shipbuilding enterprise still associated with his name, and after overcoming many difficulties the Morpeth and Egerton Docks (nearest to the river) were completed in 1847; and the central system, comprising the two great Floats and their appanages, was finished some few years later. The Docks became vested in and are under the control of the Mersey Docks and Harbour Board.

The natural groundwork of the two Floats was the Wallasey Pool, a creek of the Mersey Estuary penetrating diagonally into the Wirral Peninsula almost as far as the sea-board; and it is worth while to notice, perhaps, that the Pool has been generally regarded as the old course of the Mersey Estuary. Later and more learned research has rather discredited this theory, however; and geological opinion seems now to have crystallised round the view that the river formerly discharged into a large interior lake now represented by the wide upper reaches of the estuary, whence a stream proceeded along the Broxton Valley and discharged into the Dee at the commencement of its estuary; the present Mersey outlet being the result of sea-wear in the apex of Liverpool Bay and of a large land subsidence.

The pioneers of Birkenhead were, beyond doubt, men of initiative and breadth of view, and they laid out streets foursquare generous in width and running

parallel for miles, which are to-day, with Hamilton Square, one of the distinctive features of the town.

Another feature is the Birkenhead Park, which was laid out concurrently with the Dock Scheme. For the lay-out and design the governing body engaged the services of Sir Joseph Paxton, and the 'natural' park which resulted, some 200 acres in extent, has always been recognised as worthy of the designer in every way and as being a standing tribute to his fine instinct for landscape composition. His treatment of the lakes has attracted special notice.

No account of Birkenhead would be complete without some reference to its Mersey Ferries. The main, or Woodside Ferry, which is to-day a Goods Ferry as well as a Passenger Ferry, has passed down from the Priory of Birkenhead before referred to. The Priory retained and exercised the rights of ferriage until 1545, when Henry the Eighth conveyed them to one Ralph Worsley. The rights were eventually acquired from Worsley's successors in title by the Birkenhead Improvement Commissioners, and on the incorporation of the Borough in 1877 these rights passed to the Corporation. A steamboat service has been in operation since 1827. Until the opening of the Mersey Tunnel in 1886 the ferryboats were the only means of transit to and from Liverpool, and to-day all vehicular and heavy goods traffic is still reliant upon the ferry goods steamers. This branch of the traffic is heavy, for the ferry is a link in the westerly road from north to south, and the way from Lancashire, Yorkshire and the North generally to Chester and North Wales. The large increase in road transport within the last decade has necessitated the provision of large steamers and the provision of additional berthage on both sides of the river to deal with the congestion of traffic, and the vital importance and growing volume of the traffic has led to the consideration by the Merseyside Boroughs of the feasibility or desirability of constructing a bridge or tunnel to cope with it.

The ruins of the Priory referred to are still in existence. They have recently been restored, and are now open for inspection. They are situate near St. Mary's Church, not far from the Woodside Ferry.

The water supply of the Borough for the most part is obtained, under Parliamentary powers sought in 1907 on the advice of the late Dr. G. F. Deacon, from North Wales, close to Cerrig-y-Druidion, in the County of Denbigh. The first, or Alwen, portion of the scheme was completed two years ago, the Reservoir being approximately three miles in length with a depth at the dam of 90 feet, and a daily yield of 10·8 million gallons, of which 3·6 million gallons pass down the River Alwen as compensation water. The aqueduct, 42 miles long, passes through a tunnel under the navigable channel of the River Dee at a point near Connah's Quay, and at Cross Hill, Thingwall, just outside the Borough, there is a covered service reservoir of 30 million gallons' capacity, of unique design. This reservoir was designed by Messrs. Alexander Binnie, Son and Deacon, who, following the death of Dr. Deacon, were the engineers for the construction of the scheme. It is a concrete, brick and steel structure, hexagonal in plan. The roof is formed of 217 concrete domes built *in situ*, the domes being supported on concrete groins carried by 432 concrete block pillars.

The Borough possesses practically every undertaking or business which a Municipal body is enjoined or permitted to operate, including the supply of gas and electricity and the running of tramways and omnibus services both within and without the Borough. The Corporation have vigorously pursued the policy of their predecessors in acquiring parks, in addition to Birkenhead Park, and open spaces, and exercise control over Bidston Hill and Woods, and also over Meols Common and Thurstaston Common situate outside the Borough.

There is a good Reference and Lending Library with branches in the Town, and the Corporation recently formed the nucleus of a Museum and Art Gallery. A

noteworthy exhibit in the latter institution is a slab of sandstone bearing the footprints of a cheirotherum, the reptile of the lizard species belonging to the Secondary Period. The slab was taken from the Storeton Quarries, a mile or two away, where similar footprints are often found whenever a certain bed is reached. It is said that the nearest place to Storeton where footprints like these have been found is at Dumfries.

Owing to munificent bequests by the late John Williamson, J.P., and his son, P. A. Williamson, the Corporation are now preparing to invite designs for the erection of an Art Gallery and Museum, with which the name of Mr. Williamson will be associated, and the building will be erected within the Borough on a site very generously given to the Town by Viscount Leverhulme, whose famous Sunlight Works and Model Village are situate just outside the southern extremity of the Town.

A panoramic view of the northerly extremities of the Wirral Peninsula, of the vast Merseyside urban area, of the Irish Sea, and of the mountains of North Wales is to be had from Bidston Hill, on which the Observatory of the Mersey Docks and Harbour Board is erected. The Hill, situate just beyond the Borough boundary, is 100 acres in extent and beautifully wooded. The acquisition of the Hill and Woods, which are owned by the Corporation, was largely brought about by the untiring efforts of the late Edmund Taylor, J.P., who resided in the town, and who took the greatest possible interest in the acquisition of the Hill for the public. The Hill was purchased partly out of corporate funds and partly by private subscriptions, and is managed by a Committee consisting of representatives of the Corporation, the Vendor and co-optative Members. It is maintained wholly at the cost of the Borough.

WALLASEY.

George Livsey, LL.B.,
Town Clerk.

The districts of New Brighton, Wallasey, Liscard, Egremont, Seacombe and Poulton were each identified by their own name until ten or eleven years ago, but in 1910 a Charter of Incorporation was granted, creating the whole a Municipal Borough under the name of Wallasey, and in 1913 Wallasey was constituted a County Borough.

The population of the district has grown very rapidly, for in 1891 it was 33,000, whilst to-day it is 89,600, its popularity as a residence for those engaged in business in Liverpool increasing year by year.

The Borough is situated on a ridge of land bounded on the south and east by Wallasey Pool and the River Mersey, and on the north-west by the Irish Sea, and, as the prevalent winds are from the west and north-west, blowing directly off the sea, the atmosphere is remarkably clear of smoke. Wallasey has the record of possessing one of the lowest death rates of any town in the country.

There are three ferries between Wallasey and Liverpool, those at Seacombe, Egremont and New Brighton, all controlled by the Wallasey Corporation. The Seacombe Ferry is one of the ancient ferries of the Mersey, but the present goods and passenger ferry only date from 1879, when the landing-stage and goods accommodation was provided.

As will be seen from the very rapid growth of population, Wallasey is an essentially modern borough, indeed it has little of antiquity about it. Its Parish Church of St. Hilary, originally built in the tenth century, is about all it can claim, and of this church

very little is left, for, with the exception of the tower, it was rebuilt in 1759 and again in 1858, after a fire. The tower, of which the lowest part is thirteenth century work, has been restored and is used as a mortuary.

Leasowe Castle, on the extreme west of the Borough and situated close to the sea, which is here only kept from encroaching by an embankment, is of considerable antiquity, one of the towers being supposed to have been built by the Fifth Earl of Derby in the reign of Queen Elizabeth, and used by him as a grandstand to view the races then recently established at Wallasey as well as to stable his horses and keep his hawks. The races here had considerable popularity till the latter part of the eighteenth century, and the 'Wallasey Stakes,' established in 1723, was perhaps the earliest sweepstake. It is also worth recording that on this course, in 1683, James, Duke of Monmouth, won the plate on his own horse and afterwards offered to race the beaten jockey on foot and again won.

The oak fittings of the Star Chamber in the Old Palace of Westminster were removed here after the Chamber was abolished in 1642.

The northern portion of the Borough, facing the sea, is still known by its individual name of New Brighton, and is a seaside residential district. During the past century the character of New Brighton has changed more than once. In the early days villas and excellent residences were built on the slopes, and the locality was a residential one, but, later, cheap lodging-houses and side-shows on the sands converted it rather into the resort of the 'tripper.' More recently, however, its residential character has returned. Its situation, with extensive views of the Irish Sea, the Mersey, the long low line of the Lancashire Coast and the Liverpool Docks is splendid, and the municipality have laid themselves out to provide every attraction.

The southern portion of the Borough is more commercial than residential, and Wallasey Pool, which

borders it, has been utilised by the Birkenhead Docks. The Pool, which, before the construction of the docks was a branch of the Mersey, covers the site of an ancient forest in which bones of the red deer and two species of wild ox, as well as a human skeleton, have been discovered. Stumps of trees have been found embedded in peat under a thick covering of blue clay.

Wallasey is supplied with water from Lake Vyrnwy, by arrangement with the Liverpool Corporation, as well as with a considerable locally-pumped supply. It is lit with gas and electricity, and has an extensive tram service.

The front of the Borough facing the Mersey has been laid out as a promenade, and here is situated the fine modern Town Hall.

The Borough of Wallasey has become so much the place of residence of persons employed in the commerce of the Port of Liverpool that no account of that city would really be complete without some brief mention of its 'bedroom' across the Mersey.

THE UNIVERSITY.

J. George Adami, C.B.E., M.D., F.R.S.,
Vice-Chancellor.

The history of the University of Liverpool is the history of a new development in English academics. While Oxford and Cambridge are national institutions with ancient traditions, while London has always before it the Imperial ideal, Liverpool, in company with many of the other great provincial seats of learning, is essentially a Civic Institution, with a Charter and Constitution fitted for modern needs, a curriculum that extends over every branch of modern practical life, and a body of Staff and students that is in close touch with one of the greatest cities in the Kingdom. And in the words of Ramsay Muir's College song, it is 'Alive to the core.'

There are three outstanding features in the story of the movement out of which has grown the present University, namely, the parts played by the medical school, by a small group of influential Liverpool citizens, and by the Municipality. From 1814 onwards there had been a succession of attempts in Liverpool to give advanced instruction in literature and science through the Royal Institution and other bodies, but in the absence of adequate endowment these attempts had been doomed to failure. The solitary exception was one professional school, that of medicine, founded in 1834, in association with the Royal Infirmary. In 1871 this in its turn realised that without support from outside it could not provide the necessary instruction in the preliminary scientific subjects, and at the recommendation of Dr. Campbell Brown, its Chairman and Lecturer in Chemistry, it proposed a conference with the Association for the Promotion of Higher Education in Liverpool, a body which a few years

previously had promoted the establishment in the city of Cambridge University Extension Lectures in Science. The result of a series of conferences, at which the Reverend Charles Beard, a prominent Unitarian minister and educationist, was in the chair, was a deputation to the Mayor, Mr. A. B. Forwood, headed by Mr. William Rathbone, M.P., which resulted in a requisition asking him to call a Town's Meeting. That meeting was convened in May, 1878, and as a result it was determined in November to launch an appeal for funds to establish and endow a University College. Times were bad, and only slowly, with handsome offers of endowments for Chairs and the patriotic gift of the site by the City Fathers did the fund rise in the course of two years to the needed amount. When in October, 1881, the Charter was granted, University College started its work with an endowment (including the value of the site) of £130,000, with the fifteenth Earl of Derby as first President, Mr. G. H. Rendell as Principal, Dr. Oliver Lodge as Professor of Physics, and, following upon the Charter, Dr. Campbell Brown as Professor of Chemistry, Dr. (now Sir William) Herdman in the Chair of Zoology and Botany, Mr. Andrew Bradley in that of Modern History and Literature, Mr. John McCunn in that of Moral Philosophy, Logic and Political Economy. Besides Dr. Campbell Brown, four other members of the staff of the Medical School were given Professorships, Dr. Waters (Medicine), Mr. Rushton Parker (Surgery), Mr. (later Sir W.) Mitchell Banks (Anatomy), and Dr. Caton (Physiology).

It was natural that as the Medical School provided the first body of students and first fully-constituted faculty, the site of the College should be determined largely by its possible nearness to the Infirmary. This explains why the University buildings are situated not in the residential part of the city but in a quarter where the population is dense and poor, where there is no possibility of spacious surroundings, and where there is no frontage on to a main thoroughfare. These

are grave disadvantages, for out of sight is too often out of mind, yet the site of the University has one advantage: it is within a few minutes of the centre of the city and the main railway stations. It is thus easily accessible from all directions.

University College began its first session in 1882 with 93 day students registered on its books. It had no power to confer degrees. Those students if they wished to obtain qualifications must either be prepared for the examinations of London University, or for the diploma granting professional Colleges in London, Edinburgh and Dublin.

There is no University College which does not chafe under preparing its students for examinations of Universities and outside bodies over which its own staff has no control. But in the 'eighties, public opinion was not prepared for the foundation of independent Universities in the provinces. The most that appeared possible was the establishment of what may be termed a co-operative University with constitutent colleges in the larger centres of population. Simultaneously with the movement for the foundation of University College, Liverpool, there was proceeding a wider movement to obtain a charter for the Victoria University which should include Owens College and other Colleges in the North of England if and when they satisfied the prescribed conditions of incorporation. As a matter of fact, the charter for Victoria University was obtained in 1880. Not until the autumn of 1884 was University College in the position to seek and gain admission as a College of the new University.

Now followed a period of steady development. In 1886 was opened the first of a series of University buildings proper, the Chemical Laboratories. The same year saw the foundation of what has become the Faculty of Engineering: in 1892 the Victoria Buildings were begun, to house the administrative staff, the Tate Library and the Faculty of Arts and these were completed by the Victoria Tower, contributed by the citizens

of Liverpool in commemoration of the Jubilee of Queen Victoria. Before the end of the century there arose under generous benefactions Museums of Natural History and of Sanitary Science, the Gossage Chemical Laboratories, the Thompson Yates Laboratories of Pathology and Physiology, followed in the first three years of the new century by new Medical School Building, the Hartley Botanical Laboratory, and the Johnston Laboratories of Tropical Medicine. In 1902-3 the number of students had risen to 645, and the endowments, excluding capital invested in lands and buildings, had reached £316,000.

But throughout all these years, despite cordial goodwill, the difficulties of carrying on University functions from a distance became more and more obvious. Manchester was the official seat of the University: all meetings were held there. The difficulty of regular attendance at those meetings, their increasing number, the loss of time involved and the frequent clashing with college and other engagements in Liverpool made it increasingly evident that the three constituent colleges of the Victoria University must each seek for independent university powers. Liverpool was the first (in 1901) to move in this direction, and in 1903, with the very material aid of Lord Haldane, it presented to the Privy Council so strong a case and statutes and ordinances so carefully and wisely prepared, that in July, 1903, His Majesty King Edward VII. signed the Liverpool University charter. A few months later Manchester and Leeds dissolved partnership, each obtaining, like Liverpool, an independent University.

The outstanding feature of the constitution of the University as laid down by the charter is the division of administrative authority whereby a Council of 30 members controls the finance, and a Senate composed of the professorial staff, together with the Deans of the various faculties and the Librarian (who need not necessarily be of professorial rank) controls all educational and disciplinary matters, subject to review by the Council. The Vice-Chancellor is a member of

Council and Chairman of the Senate and intermediary between the two bodies. Unlike some of the Vice-Chancellors of the older Universities and the Presidents of many American Universities, he has no autocratic powers. Over and above all is the Court, a large body consisting of representatives of various interests throughout the district served by the University—Members of Parliament, County Councils, Municipalities, Bishops and heads of the various Churches, Directors of Education and Chairmen of various Educational Committees, Presidents and Chairmen of various Hospitals and professional bodies, Principals and Headmasters of various Scholastic Institutions, representatives of Teachers' Associations, of United Trades and Labour Councils, members of the Council and professorial staff, representatives of Convocation and of the Guild of Undergraduates, together with all benefactors of £1,000 and upwards. The Court meets at least once yearly and is the supreme governing body of the University, having authority to confirm or disallow the proceedings of the Council and University where these are not governed by the Charter and Statutes. While it has extensive powers, these are rarely exercised save in the ratification of business brought before it by Council. It is there as an ultimate court of appeal should Council be thought to exceed its powers or should Council and Senate disagree.

Council consists of thirty members, of whom one-sixth are University officials (Chancellor, Pro-Chancellors, Vice-Chancellor and Treasurer), one-sixth nominees of the Municipal Council, one-sixth representatives of the Senate and Faculties, and one-half citizens of prominence of Liverpool and district, appointed by the Court. The Council, it should be added, has the ultimate appointment to professorial Chairs and lectureships.

Under the Senate are the various Faculties, of Arts, Medicine, Science, Law and Engineering—and in addition to the Faculties and under one or other of them are sundry departments, Education, Architecture,

Dentistry and Veterinary Medicine, which, as they expand and increase their staffs, may eventually arrive at Faculty rank. Each Faculty, subject to the approval of Senate, administers its own educational affairs, and, through Senate, makes recommendations to Council regarding its needs. By charter, Theology as such, is not recognised by the University, although teaching is given in such subjects as Hellenistic Greek, Semitic languages, and Ecclesiastical History. It is, further, a fundamental condition that no religious test shall be imposed on any Member of the University, whether it be Professor, Teacher or Student.

Under this system, with increasing support from private benefactors, the Municipality and other local authorities of the district served by it, and the Treasury, the University since its establishment in 1903 has exhibited steady growth. In 1903-4 the students registered (excluding evening courses) were 638, in the session 1922-23 the number is nearly quadrupled. In 1903 the number of professorial Chairs was 31, to-day it is 58, and whereas the total income in 1902-3 was about £30,000, in 1922-23 it is over £200,000.

Space forbids that I should register here the successive great benefactions received by the University in the last score of years, the individual endowments for buildings, professorships and scholarships, the princely help received from great Liverpool merchants and their families, the Rathbones, Holts, Brunners, Muspratts, Tates, Booths, Harrisons, and Hughes, Charles and Sydney Jones, John Rankin, Lord Leverhulme, Sir Alfred Jones, Sir William Herdman, the late Alderman Cohen, and others; the difficulty lies in knowing where to end the list. Inevitably, progress was arrested by the Great War, but this was followed by a vast expansion in numbers, no less than 1,200 ex-Service students being accepted as full-time students, and the resources of the University and its staff were strained to the uttermost. Nor with the graduation of these students has there followed any material diminution in the number of registered students, for the

improvement in secondary education in England since the beginning of the century has led to a marked and continuing increase in those prepared and anxious to take advantage of University education, and since the War, Universities, like Schools, have been filled to overflowing.

Space again forbids that there should follow a detailed account of the various University buildings and activities. It has already been explained that the University cannot boast about its site or the beauty of its buildings. 'Mind and not matter' has been the motto. Its buildings have not been given time to become even handsomely ugly: they are too crowded together to exhibit what good points they possess. But with rare exceptions they are—or were—well planned and adapted to their special uses. I say 'were' because with the great increase in the student constituency there is hardly any department but is becoming too small and overcrowded.

Certain special features may, however, well be noted:—

1. The fact that this is a civic University does not in any sense imply that the modern, scientific and professional departments have been developed at the expense of the 'humanities': the Arts Faculty is still the most numerous, with 795 students as compared with 459 in Science, 583 in Medicine (exclusive of Dental and Veterinary students), 210 in Engineering and 51 in Law.

Saying this the University has fully recognised its duties as a civic university in preparing students for professional careers and for professions uncatered for by the older universities.

Special reference must be made to the following departments as special developments in the University:—

The Department of Educational Studies. An increasing number of those intending to be teachers seek to possess a University degree, and the Board of Education aids those who wish to be teachers in, more

particularly, secondary schools, by Government grants, by which the University fees are paid in full and maintenance in part for a three years' course in Arts or Science, and a year of training in the Theory and Practice of Pædagogy under the Professor of Education and his staff. The well-equipped—not to say beautifully-equipped—Department of Education in Abercromby Square well deserves a visit.

The Department of Architecture. This, an outcome of one of the first-established Chairs—the Roscoe Chair of Art in 1881—has, since it establishment in 1904 and the appointment of the present Professor, grown steadily until its reputation as a centre for neo-classical or 'Beaux Arts' architecture has extended throughout the Empire. As a result, the majority of its 100 students come from outside the University district proper. Closely associated with the School of Architecture is the Department of Civic Design, which owes its inception in 1909 to the evident demand which exists for a system of training in the broader aspects of Architecture and Engineering, with special reference to Town Planning. The full development of the School was made possible in 1912 by the endowment from Lord Leverhulme of a Special Chair in this subject.

The School of Chemistry. Liverpool is the centre of the 'heavy' chemical industry, carried out at Widnes, Runcorn, St. Helens, and Fleetwood, while similarly Widnes and Port Sunlight have made Liverpool the great centre for fats, soaps and oils. Chemistry has thus become the most favoured subject in the Faculty of Science, with Chairs in Inorganic, Organic, Physical and Bio-Chemistry, and yet another Chair about to be founded in Applied Chemistry, out of a trust established by the late Professor Campbell Brown, who may be regarded as the first founder of University College. The accommodation in the old Muspratt and Gossage Laboratories being all too small it has been necessary, in spite of post-war difficulties, to

begin the building of a new laboratory, and the first block so built is already filled with graduate research students.

Oceanography. The position of Liverpool as a seaport and the year-long interest of our Emeritus Professor of Zoology, Sir William Herdman, in Marine Zoological investigation, first at Hilbre Island and since then for many years at the station established by him at Port Erin, Isle of Man, has led to the foundation of a Department of Oceanography of which Sir William became first professor, ceding the Chair after a year to the present occupant. The work of the department is carried on both at Liverpool and Port Erin, and in addition to research and classes in Marine Zoology (at Port Erin) short courses are given to those interested in fisheries upon Economic Marine Zoology.

Refrigeration. The transport of perishable foodstuffs in a great port like Liverpool is a matter of prime importance, and in 1920 there was established in the Engineering Faculty the John Williams Hughes Chair of Refrigeration, with a laboratory for the special study of this subject.

The Tidal Institute is another feature of our seaport University. Established in association with the University by several of the leading members of shipping firms, the study of the theory of tides by the head of the Institute and the Secretary have led to most important corrections in the estimation of high tides along the British coast, so much so that the Admiralty is making extensive use of the charts and estimates of the Institute for the material benefit of British shipping in general. A combined Committee of the Mersey Docks and Harbour Board has this year been formed to carry on the work both of the Institute and the Observatory, which for many years has been operated under the Board at Bidston.

The School of Tropical Medicine. Liverpool can boast of being the first city in the Empire to establish a School of Tropical Medicine, and this through the

breadth of vision and support of one of its great merchant princes, the late Sir Alfred Jones, through the missionary enthusiasm and administrative ability of the late Sir Rubert Boyce, its Professor of Pathology, and the hearty support of the then Colonial Minister, Mr. Chamberlain.

If only for what that school accomplished in its first years in laying down the rules of life for sailors and the representatives of commercial firms visiting the Coast of Africa and the Tropics, it has returned many times the sums expended upon it by the great African and other firms dealing with the Tropics. As an example of this may be mentioned the work of Sir Ronald Ross, its head, and Sir Rubert Boyce, both pioneers in the suppression of mosquitoes and the arrest of malaria. But in addition, the School has dispatched some three dozen expeditions to Africa, to tropical America and elsewhere, and has by means of them accomplished valuable work, more particularly in extending our knowledge of Tick Fever, Sleeping Sickness, and other forms of Trypanosomiasis. It has established a laboratory and research centre at Manaos in the heart of Brazil, and its last notable development is the opening of a laboratory at Freetown, Sierra Leone, to serve not merely for research into the diseases of the West Coast of Africa, but also as a centre for training in tropical hygiene. The head of that laboratory *ex-officio* holds the Chair of Tropical Medicine in the University of Liverpool, which thus now possesses a colonial offshoot. The newly-erected buildings of the school in Pembroke Place were during the War placed at the disposal of the War Office and converted into a hospital. Only in 1921 were they fully equipped and opened. They well repay a visit.

The School of Veterinary Medicine.—To the keen interest taken by the late Sir Rubert Boyce in comparative pathology and his recognition of the lack of sound training in the preliminary sciences obtainable in the isolated veterinary schools of the kingdom is due the

establishment of the Liverpool University School of Veterinary Science, whose students receive in their early years the same courses in science as do the students in medicine. Liverpool, in fact, is the only university in the kingdom which offers the complete degree in Veterinary Science obtainable at the end of a five years' course.

The School of Dentistry. With a like recognition of the great need of dentists who have been trained in science as well as in practice, and with the cordial support of the leading dental practitioners in the city, the University has followed the lead of many of the foremost Universities in America and in the Dominions in granting a licentiateship and degree in Dental Science. During the first three years the students take the same courses as do the medical students in their first two years, the dental students having in addition to devote much time to laboratory work in dental mechanics. Thanks to the generosity of the late Alderman Cohen, Liverpool possesses the first fully-endowed Chair in Dental Surgery.

Unlike physicians and surgeons, dentists reap little ultimate gain from giving their time to teaching in a school or hospital; dental consultants are unknown, and old pupils do not send difficult cases to their old teachers. It is to the singular great credit of the teaching staff of the Liverpool School that they contributed their share of the students' fees accumulated over long years to the building of an admirably-designed new laboratory in association with the Dental Hospital in Pembroke Place.

Research. A few words may be said with reference to the part played by the University in the advancement of knowledge. From the first the regulations for the mastership and higher degrees have very definitely encouraged research in the various faculties, in arts as well as in the sciences. Since the War this has been notably augmented, by the wise and generous policy of the national committees of Scientific and Industrial

Research and Medical Research respectively, and in the second place by the establishment by this and other Universities of the Ph.D. degree. It is interesting to note that whereas this latter was established in the expectation that it would attract advanced students from the Dominions and the United States, its first result has undoubtedly been to encourage our own graduates to spend two years at original work. This is particularly the case in the various branches of chemistry, but there are numerous workers in Botany, Zoology, Geology, Pathology, Bacteriology and other sections of Medicine. Mention may be made here of a co-ordinated research by the heads of various laboratories into problems connected with the arrest of malignant growths. In a wholly different direction the department of English has become the centre of a national movement for the collection and study of place names from one end of England to the other, and the publication of reports on methods and materials gleaned from the different counties.

Student Life. One last paragraph may well be devoted to student life and activities. By the Charter of the University the undergraduates were to be united into a Guild or Guilds, and thus from the first it was sought to give a considerable measure of self-government to the student body. As a matter of fact, under a succession of able Presidents and Councillors of the Guild, elected by the undergraduates from among themselves, this system of self-government has developed to a remarkable degree. Only in exceptional circumstances are the Vice-Chancellor and the Discipline Committee of the Senate called upon to take action. All minor breaches of discipline are dealt with by the student body itself. The Guild with its two Presidents, appointed by the men and women students respectively, deals with all the various student activities. The various years and the various societies are represented upon the Council. All these activities are centred in the Students' Union, which, however, with the

great growth of our University, has become all too small.

The athletic life of the University has been given great encouragement and development since the War by the generous provision of magnificent grounds at Wyncote, Allerton, some twenty-five acres in extent, with club-house and cricket pavilion. This was given by Mr. Harrison Hughes in memory of a brother who died in the War.

EDUCATION.

(other than University).

J. G. Legge, B.A., C.C.,
late Director of Education for Liverpool,
and
C. F. Mott, M.A.,
Director of Education for Liverpool.

Public education on Merseyside is in the charge of seven Local Education Authorities—the Liverpool City Council, the County Borough Councils of Birkenhead, Wallasey and Bootle, the Urban District Council of Waterloo-with-Seaforth, and the County Councils of Cheshire and Lancashire. On the first four of these rests the duty of providing for the educational needs of the great bulk of the Urban population of the area numbering over a million persons; each of these Authorities is autonomous within its own boundaries. and has power to deal with all forms and grades of education recognised by the law. The Waterloo-with-Seaforth Council provides Elementary education for a population of 30,246, and shares in the administration of Higher Education with the Lancashire County Council, with whom the chief financial responsibility lies. In the remaining suburban districts, including such important localities as Port Sunlight on the Cheshire side, and Litherland and Formby in Lancashire, the County Councils exercise undivided powers.

But although the Authorities are many, the community is, in a broad sense one: the parts into which it has been divided by the operation of geographical or historical causes being bound together by the closest

ties of common interest. There is, therefore, both need and opportunity for co-operation between the Authorities, and for co-ordination of their activities. Working arrangements have been entered into in respect of a number of points of detail, but the question is one which calls for systematic treatment; and for this, machinery has been created by the formation of the 'Merseyside Municipal Co-ordination Committee,' set up jointly by the City and the County Borough Councils.

In the present brief survey, it will perhaps be convenient if we deal separately with the educational provision of each municipal area, beginning with Liverpool itself. For information regarding the adjoining areas, we are indebted to the Directors of Education for those areas.

We shall best understand the characteristic features of the educational system of Liverpool if in considering them we keep in view the history and the social and economic conditions of the City. Although as long ago as 1173 A.D. of sufficient importance to receive a Charter, Liverpool has grown to its present dimensions almost entirely within the past two hundred years, and by far the greater portion of this growth has taken place during the latter half of the nineteenth century. And, unlike other large manufacturing towns of the North of England and the Midlands, Liverpool has no predominating industry in which the workers enjoy some measure of security of tenure and regularity of employment. The principal occupation of the City, and that upon which its prosperity depends, is concerned mainly with the handling of goods, their loading on ship, their unloading and transfer from quayside to warehouse or railway. All these operations require 'unskilled' labour (so-called—though as a matter of fact much of the work requires real skill) and such employment tends to be irregular. The result is that the proportion of casual workers among the population has been unusually high; the problems arising in a community of this kind are well known,

and they have perhaps taken a more acute form here than in any other part of the country.

One effect of these conditions has been to give a social side to almost every branch of local government and particularly to education. As the City rose to its commercial predominance long after the wave of educational philanthropy of the middle ages had spent itself, it has practically no educational endowments, and in this way differs materially from cities like Birmingham, Bristol and Sheffield. The philanthropic activities of its public-spirited citizens of bygone days were directed towards the relief of the poor and destitute, and of orphan children, and in this respect Liverpool is extremely well equipped.

The peculiar educational problems of the City have, however, had one extremely important effect in giving an impetus to certain pioneer movements in educational reform. Time after time educational experiments have been instituted to meet some particular need, and after experience has proved them to be successful, they have been embodied in educational legislation, and have thus become part of the national scheme. In this way we find the first school in England for the education and training of the blind established in Liverpool. The first attempt to cure truancy by the institution of a Short-Term Industrial School was a Liverpool achievement, as also was the establishment of the first Day Industrial Schools. It was here also that a successful experiment was introduced to regulate trading in the streets by children, a reform which was afterwards embodied in the Employment of Children Act of 1903. The introduction into the Elementary Schools of organised science teaching and of practical instruction in woodwork and metalwork for boys, and cookery and laundry-work for girls, was also a Liverpool innovation, which had to receive legislative sanction after it had been decided to be outside the educational powers of the Local Authority. It was in Liverpool also that the extremely valuable social work of emigrating children from residential industrial

schools was first instituted. By this means many hundreds of young people have become creditable citizens of the Dominion of Canada who, had they been allowed to return to the undesirable surroundings from which they had been rescued, would undoubtedly have been overwhelmed in the social whirlpool.

Reference may be made here to the Liverpool Council of Education, a 'semi-official' body administering endowed funds, who have contributed a valuable share in the initiation of new departures. The development of the 'scholarship ladder' from the elementary school to the University, the improvement of school attendance, the institution of School Savings Banks, owe much to their labours.

The first serious attempts to cope with the educational destitution of the masses of the people were made towards the end of the eighteenth century and in the early decades of the nineteenth; of these efforts Sir Michael Sadler has remarked that they were 'unsurpassed elsewhere in England.' Among the schools built at this time, and still in use, we may mention the Old Church School, erected in 1789; the Harrington School, first opened in 1807; the Hibernian School (now the Pleasant Street Council School), erected in 1811; and the Caledonian School, which dates from 1812. These schools, and the others numbering nearly 100 which were established before 1870, were of course—with two exceptions—provided by voluntary agencies, and particularly by the chief religious denominations. But the City Council has an honourable place in the records of the time, in virtue of its founding in 1826 of the two free elementary schools long known as the 'North' and 'South Corporation Schools.' The premises of these schools, situated in Bevington Bush and Park Lane, respectively, may still be seen, though not now in use for ordinary school purposes.

After 1870 the work of the voluntary agencies was supplemented by that of the Liverpool School Board, and the achievements of that body and of their

successors the Education Committee have kept Liverpool, in spite of the rapid growth of the population, abreast of its needs by the building and equipping of some 64 public elementary schools. The magnitude of their task may be estimated by the fact that it has involved a capital expenditure of over £1,450,000.

The population of Liverpool, according to the 1921 census, is 803,116, and its present public elementary school accommodation consists of 141,683 school places which are supplied by 63 Council Schools and 101 Voluntary or Non-provided Schools. The actual number of scholars enrolled is 137,238, of whom 66,076 attend Council Schools, and 71,162 Voluntary Schools; the total average attendance for the year ended 31st March, 1923, was 124,205. The working of these schools entails the employment of a staff of 3,270 teachers.

The schools themselves provide many features of interest in their planning, organisation and curriculum. There are examples of the small rural school, accommodating some three score scholars, as at Fazakerley C.E., and the huge educational organisation only possible in a densely populated residential district such as the Arnot Street Council School, which provides for a daily roll of 2,470 scholars. Various phases of school architecture are illustrated: there are schools with central halls around which classrooms, etc., are grouped, such as Birchfield Road, Lister Drive, and Banks Road Council Schools; schools with a gymnasium attached, such as Arnot Street, Lawrence Road and Anfield Road; schools of the single storey type, such as Rice Lane, St. Michael's Hamlet and Longmoor Lane; and schools of the more recent type in which a marching corridor is provided, examples of which type are to be found in the 'Harrison Jones' Council School, and in Netherfield Road and Wellington Road Council Schools. An interesting example of the conversion of a pair of old houses into an elementary school may be seen in the Everton Terrace premises. A comparison

of some of the earlier buildings with premises like those of Birchfield Road and Lawrence Road with their assembly hall and gymnasium, swimming bath, and chemistry and physics laboratories, and domestic science and manual rooms shews at once the development which has taken place during the century or so of greater educational ideas, and the large-minded conceptions which have in recent times actuated the Local Education Authority and its Voluntary coadjutors.

The schools also afford examples of interesting departures from the normal in point of organisation. The Provided Schools, for instance, include a number of large Mixed Schools of a type not uncommon in Scotland, though rarely seen in England. These schools for convenience in working are divided into departments in various ways, and the special responsibilities of the 'First Masters' or 'First Mistresses' in charge of departments are recognised by the payment of special salaries: but the whole direction and control of each school is in the hands of a single Principal, so that the curriculum can be planned as a coherent whole, and the work of the several departments fully co-ordinated. Further advantages have been claimed for these schools in the matter of classifying pupils according to ability, and in respect of economy of staffing, but at the present time it is doubtful whether the schools can be maintained at less cost per pupil than an ordinary large departmental school.

As regards curriculum and instruction, much has been done in recent years to broaden the subject matter and to infuse interest and life into the teaching. Initiative and enterprise in trying new methods and making experiments have always been encouraged by the Authority, and as a result many schools exhibit a strongly marked individuality. In a number of Infants' Departments the Montessori System has been incorporated in the school work with success. In departments for older children, simple science teaching, manual training, mainly in the form of woodwork, and domestic work in the form of cookery, laundry and

housewifery occupy important positions. No fewer than 10,000 scholars of each sex receive instruction in practical subjects each year. The premises used include 35 woodwork rooms and centres and 64 domestic science centres, besides the special accommodation provided in many of the newer schools.

No central schools have been established, but advanced instruction is given to 836 scholars nearly all over 14 years of age, by means of central classes provided in nine of the Elementary Schools.

The Education Committee have paid much attention to the physical training of the scholars, and this side of their work has been brought to a high pitch of efficiency by the enthusiasm and energy of the teachers and the Committee's organising officers. Organised games form part of the ordinary curriculum as well as formal physical exercises. Three large playing fields have been acquired by the Committee for the special use of the Elementary scholars; and in each week during the midsummer vacation about 30,000 children are taken to the Parks, playing fields and open spaces for organised games under the supervision of teachers, free transport being provided by the Committee. Swimming is also taught in school hours, about 12,500 boys and 4,500 girls receiving a lesson in one of the public baths each week; and largely owing to the enthusiasm and energy displayed in the Garston Ward of the City, where Mr. W. J. Howcroft has played a leading part, Liverpool schools hold to-day a pre-eminent position in this sport.

In developing physical training the Committee have received valuable assistance from the teachers' organisations, who have promoted inter-school and 'league' competitions, sports tournaments and swimming galas.

Nor has this assistance been confined to the physical side. The love of music and art has been fostered by a voluntary organisation composed of teachers and others called the Art Studies Association, who arrange recitals of music for the children and also Art Exhibi-

tions and lectures. The high standard of the music teaching is demonstrated each year in the Massed Singing Festivals held at the St. George's Hall, under the auspices of the National Union of Teachers, and the National Association of Schoolmasters, in which some hundreds of pupils from the City Schools take part.

Mention must be made of the success of the Education Authority in securing the attendance of children at school, a task which is always a difficult one in a large seaport town, where a great portion of the population is migratory in habit. Liverpool was the first authority to exercise its statutory powers in making Bye-laws for the regulation of school attendance. Ever since the passing of the Act of 1870 periodic house to house visits have been made to ensure that all children of school age are receiving education. In 1871 the percentage of attendance at the public elementary schools was 52·7 per cent., in 1892 it had risen to 85·2 per cent., while last year it reached 91·3 per cent., a result which is comparable with that attained in other large Cities where the population is more stable.

As already stated, efforts have been made in Liverpool from an early stage in educational development to meet the special difficulties which are inevitable in centres containing a large number of casual labourers. No City in the kingdom has done more in the way of public recognition or public support of schools and institutions for poor or neglected children or for children suffering from physical or mental defect. As already mentioned Liverpool was a pioneer in the establishment of Day Industrial Schools; these schools resemble ordinary Elementary Schools in that they are non-resident, but differ from them in that they retain their pupils for the whole of the day, not merely during school hours, and in that they provide meals as well as education. The instruction given, moreover, includes simple industrial training as well as the usual subjects of the Elementary Schools. The Authority have no doubt of the value of these schools in counteracting

some of the more serious effects on the children of poverty or of neglect on the part of the parents. In all, five Day Industrial Schools have been established in Liverpool, and all were at work until recently, but in the view of the Home Office the need for schools of this kind has diminished of late years, and there are now only two in use, Addison Street and Queensland Street, with accommodation for 580 children. The Short-Term Residential Industrial School for boys referred to in an earlier paragraph is situated at Hightown, some nine miles from the City: boys committed here (usually for habitual truancy) are detained as a rule for a period of four months in the first instance, but they remain under the supervision of the Managers until they are 16 years of age.

Of the ordinary long-term industrial schools for juvenile offenders, there are six in the vicinity of the City, and also five reformatories. These have all been provided by voluntary agencies, and are not under the management of the Committee, though recognised and supported by the City Council. As in other branches of the educational work, various activities are carried on in connection with the Industrial Schools by voluntary agencies, one of which provides and arranges a holiday camp and another maintains a clothing fund.

The Educational Authority assists in the emigration of suitable ex-pupils of these schools; 1,464 children have been emigrated since 1892 through the Liverpool Sheltering Homes' Committee and the Catholic Children's Protection Society.

As to education of children afflicted by physical or mental defect, it may be mentioned that long before statutory provision had been made for such a course, spectacles were provided by the Liverpool Authority for children with defective sight, whose parents were too poor to procure them. Special classes for pupils with defective vision have been arranged at the Birchfield Road Council School, while provision is made for children who are definitely blind by two voluntary bodies at the School for the Blind, Wavertree, and the

Catholic Blind Asylum, West Derby. A school for deaf children is controlled and maintained by the Authority at Crown Street. Education and a mid-day meal is provided for other physically defective children and for the mentally defective children in five 'Special' Schools, and a motor ambulance conveys those who are unable to walk to and from their schools.

The Committee have always had the invaluable co-operation of the Invalid Children's Association (now the Child Welfare Association), well known beyond the boundaries of the City; and a residential country school, set up in the first instance by the Association in premises at Bowring Park provided by the City Council, is now maintained by the Committee. This institution is used as a recovery school to which children are sent from other Special Schools for periods of about 12 weeks, and the children are found to improve so considerably in health from this treatment that about one-third are usually able to return to the ordinary elementary schools. The school will shortly be removed to new premises at Woolton Vale, Calderstones Park.

Free meals for necessitous children are provided by the Education Committee at 18 centres. The selection of the children is made in the first instance by the Head Teachers, who then report the cases to headquarters, and the family circumstances are investigated by the Education Committee's officers. The meals are cooked at the Day Industrial and Special Schools and served either at these schools or distributed to other premises. In this way about 1,500 children are catered for daily at a total cost of some 3½d. per meal.

Turning to Higher Education, we have already noted the serious hindrance to development that has arisen from the lack of endowments, the absence of which has made Secondary School education a problem of singular difficulty. It is true that in the early part of the sixteenth century an endowment was left for a Grammar School; this consisted of lands which were afterwards included in the Corporation estate. The

school thus founded went out of existence in the beginning of the nineteenth century, and the Corporation discharged its liability by the establishment of the two free Elementary Schools already mentioned. The oldest of the Liverpool Secondary Schools now in being —Liverpool Institute—was established in 1825, and was followed in 1843 by the Liverpool College. The Institute and its companion High School for Girls at Blackburne House were transferred to the Education Authority in 1903, and a section of the College foundation, the Collegiate School, similarly transferred in 1906. The Collegiate building, in Shaw Street, is an excellent example of the architectural work of H. L. Elmes, who has left so enduring a monument of his genius in the St. George's Hall. The Collegiate School provides for about 1,000 pupils, and is the second largest State-aided Secondary School in the country. The rest of the public system of Secondary Schools has been provided out of the City rates. It includes two Boys' Schools, the Alsop High School at Walton (named after the late Alderman J. W. Alsop, Chairman of the Education Committee, 1913-1920), and the Quarry Bank High School at Calderstones Park; four Girls' Schools —Aigburth Vale High School, Sefton Park, opened in 1908, Queen Mary High School, Anfield Road, opened by H.M. The Queen in 1910, and two newer Schools, the Calder School, Calderstones Road, and Holly Lodge School, Queen's Drive, West Derby; and two Mixed Schools, the Holt Secondary School, and the Oulton Secondary School. On the rolls of these Municipal Schools, numbering 11 in all, there are over 5,000 pupils. In addition, the City contains a number of well-known Secondary Schools maintained by Governing Bodies other than the City Council. These include the Liverpool College for Boys, Sefton Park Road, one of the newer English Public Schools, and its sister school, the College for Girls at Huyton; the two large Roman Catholic Schools for Boys, St. Francis Xavier's and the Catholic Institute, and the Girls' Schools of the same religious denomination, Notre Dame High School and

Collegiate School; the Belvedere High School for Girls of the Girls' Public Day School Trust; the Colleges for Girls in Grove Street and at Fairfield, maintained by the Liverpool College Governors; and St. Edmund's College for Girls in Colquitt Street.

All the larger schools carry their instruction to the standard of University Entrance Scholarships, in some on the lines of the Advanced Courses of the Board of Education, in others on independent and individual lines. The total number of school places in 'aided' and 'provided' Secondary Schools is now nearly 10 per 1,000 of the population, a figure which represents about the average for England and Wales as a whole.

The Education Authority and the Council of Education have co-operated in providing an extensive system of scholarships leading from the Elementary Schools to Secondary Schools and other schools of similar grade, and from the latter to the Universities.

In reference to Technical Education, one of the cardinal facts is that Liverpool is really a very considerable home of industry, although it is not customarily so regarded; the reason is that no one industry predominates markedly over the others, but the City is a great home of small trades, resembling in that respect East London. Technical education starts in the Evening Continuation Schools, leading on to Branch Technical Schools, where systematic instruction begins in subjects connected with engineering, the building trades, etc.; the highest grades of this instruction are provided in the Central Technical School. The work at the Central School in engineering, building construction and industrial chemistry, has been rapidly developed since the cessation of the war, and is now equal to that attained in any Technical School in the country. The Central Technical School also houses the School of Marine Engineering and the Nautical College, both of which hold an outstanding position in the country; there are also very successful courses of training for ships' cooks and stewards carried on in

another building, and in accordance with the regulations of the Board of Trade.

There were rather more than 5,000 individuals in attendance last winter at the Evening Continuation Schools; among these schools the 'Handyman' classes at Northumberland Street may be specially mentioned. The class entries at the Branch Technical Schools for industrial and domestic subjects numbered about 1,630, together with over 1,500 in commercial subjects. There were over 1,500 students in attendance at the Central Technical School, the great majority of whom were taking approved courses of work extending over two or three evenings a week.

There are also three Junior Technical Schools numbering 200 each, where boys receive a two years' course of practical instruction so arranged as to terminate at an age just prior to that of apprenticeship. In the development of this liberal alternative to what is known under the Board of Education's regulations as Secondary Education, Liverpool has played a most prominent part.

Commercial instruction begins in the Evening Continuation Schools, is carried on in the Commercial School and in the Branch Technical Schools, and leads to a series of Advanced Courses which are carried on at present, through lack of a suitable centre, in several premises, where provision is made for Bankers' Classes, for classes in shipping and railway management, Insurance Classes, Secretarial work, Accountancy and so forth. A School of Languages is held in an office suite in Exchange Buildings, in the very heart of the commercial centre of Liverpool, and provides instruction in the chief European languages of commerce both by day and evening classes. But the Committee is conscious that Commercial Education in the City cannot be expected to hold the position it ought to until a well-equipped central building is provided.

The School of Art in Mount Street provides comprehensive instruction not only in pure Art, but in

a great many forms of artistic craftsmanship, including jewellery and silversmith work, wood and stone carving, book-binding, typography, lithographic drawing and painting, book illustration, painting and decorating, lace making and embroidery. There is a preliminary class for young people who are not quite ready to take the standard of work in the School of Art itself.

The Education Committee have for the past ten years or more maintained a Juvenile Employment Bureau with the object of giving advice to boys and girls as to the choice of suitable employment, and of placing them in suitable occupations when they leave school or up to their eighteenth birthday. To enable this to be done effectively, close relations have been established with employers generally in the City, and so far as the state of industry will permit, employers have shown a readiness to avail themselves of the services of the Bureau. During the last ten years the total number of boys and girls who have been interviewed and advised on matters relating to their employment has been 65,000, while there have actually been over 31,000 juveniles placed during that period in situations directly through the Bureau. The figures for the past year show that over 9,000 boys and girls were personally interviewed in this way, and it is significant that the number applying from the Secondary Schools has shown a larger proportion of increase. While the state of trade has made it impossible to place the whole of these applicants, many of whom are still being dealt with, yet, considering how serious the depression has been and how little evidence there is as yet of a recovery, the fact that for some months past vacancies have been filled at an average rate of 35 per week, bears remarkable testimony to the utility of the Bureau and the public confidence it enjoys. It should be added that the juvenile employment scheme is carried out under statutory authority, and that most of the important employers' associations of the City are represented upon an advisory committee for the work.

The medical inspection of the pupils in both the Public Elementary and the Secondary Schools is carried out under the Education Committee, the Medical Officer of Health of the City being also Medical Officer to the Education Authority, an arrangement which ensures the closest co-operation with the Health Department. Twelve medical inspectors are engaged in the work of examination. Every child in attendance at these schools is thoroughly examined at least three times during his or her school life.

The parents are promptly notified of any defects discovered and urged to obtain treatment as soon as possible. For those children whose parents are unable to afford treatment privately, the Committee have provided Clinic treatment if they suffer from the following defects:—Minor ailments, certain skin diseases, defective eyesight, enlarged tonsils and adenoid growths, ear troubles and dental defects. During the year 1922 over 29,000 children received clinic treatment for these defects.

The School Nurses, who form part of the staff of the Health Committee, attend at the various Clinics, assist the Medical Officers in their work at the schools, and pay special visits to the homes with the object of giving the parents friendly advice and explaining the necessity and the methods of carrying out any treatment advised.

Full details of the work will be found in the Annual Report of the Medical Officer.

There are three Training Colleges for teachers in the City besides the Training Department of the University, namely, Edge Hill College, the Roman Catholic College of Notre Dame, and the F. L. Calder College of Domestic Science maintained by the Education Committee. The Calder College was the first establishment of its kind in the country. It began as a School of Cookery in 1875, and through its activities the Government were persuaded in 1882 to make a special grant in aid of the teaching of domestic science. It afterwards developed into the first Training College

of Domestic Science in England. The present premises in Colquitt Street were built and equipped in 1900. The college was carried on by private enterprise until 1920, when it was transferred to the Liverpool Education Committee and named after the founder, Miss F. L. Calder. It is a recognised training college for teachers of domestic science, and in addition provides a number of general classes in domestic subjects for students not desirous of qualifying for teachers.

The well-known Liverpool Physical Training College, under private management, has premises at Bark Hill, Aigburth, and in Bedford Street.

Birkenhead is situated on the western bank of the River Mersey, and is the largest and most important town in Cheshire. In 1877, it was incorporated with the townships of Claughton, Oxton, Tranmere, and that part of Higher Bebington usually known as Rock Ferry. It became a County Borough under the Local Government Act in 1888.

In 1831, it was a village of little over 200 inhabitants, but with the opening of the docks in 1847 the district rapidly developed, and in 1861 the population had increased to 51,649, in 1901 to 110,926, and in 1921 to 147,800. The main occupations of the inhabitants are in connection with the very extensive docks, with the shipbuilding, ship-repairing, engineering, milling, and building industries; with the importation and landing of cattle both for slaughter and distribution, for which Birkenhead is one of the leading centres in the Kingdom; with the shipment of coal which is largely exported; a large proportion of the residents are employed in the commercial life of the Port of Liverpool; many are engaged in the professions, in transport work, and in shop-keeping.

Birkenhead was one of the latest of the large towns in the Kingdom in which a Local Authority for education was formed, the first School Board being elected in May, 1893, after the failure of strenuous efforts to provide voluntarily for the deficiency which had arisen

in elementary school accommodation. Similar efforts made in the years 1871 and 1879 had been successful in meeting such requirements and of postponing the establishment of a Local Authority under the Education Acts. The result is that even now a large proportion of the school provision is supplied by voluntary (or non-provided) schools. The first of such schools, St. Mary's, was opened before 1830, eighteen schools were opened between that date and the passing of the first Education Act of 1870, and six additional schools were provided previous to the formation of the School Board in 1893. Since that time two new Non-provided Schools have been erected, additions have been made to eight schools, while eight schools have been closed. The accommodation in Non-Provided schools in 1893 was 15,495, and is at the present time in 19 schools 12,715 (C. of E., 7,122; R.C., 4,310; Und., 1,283).

The School Board was superseded as the Local Education Authority by the Council of the County Borough on the 1st April, 1903, under the provisions of the Education Act of 1902. Under this Act the duties of the Local Authority not only embraced the powers which had devolved upon the School Board of making adequate provision for elementary education, but extended those duties to include the provision and co-ordination of all forms of education. The School Board during its ten years' existence had made provision for school accommodation for 7,396 scholars, including a school for the instruction of mentally defective children, with accommodation for 130 individuals. To this provision the Education Committee have made additions, and there are now 17 Council Schools consisting of 36 departments providing accommodation for 13,896 scholars.

In general, the Non-Provided schools have been organised in departments for Boys, Girls and Infants. The School Board introduced large mixed departments with accommodation varying from 500 to over 700 for older scholars, with an Infants' department attached.

The more recent schools contain, however, separate departments for the boys and the girls. Full provision was made for instruction in Woodwork for all boys, and in Domestic Economy for all girls, from the age of between 11 and 12 years. Practical work in School Gardening was introduced largely during the war, but owing to the restrictions on sites for gardens it has since been somewhat curtailed, and is at present taught in connection with six schools.

To meet the requirements of the Education Act of 1918 for advanced and practical instruction for older and more intelligent scholars, and the raising of the compulsory age of school attendance to 14 years, the Authority have commenced a re-organisation of the schools, under which scholars, after passing through Standard V (i.e., between 11 and 12 years of age), and all other scholars over 12 years of age, are transferred to Central Schools for Boys and Girls, respectively. Under these arrangements the older scholars are classified according to their attainments, and the necessity which has hitherto prevailed in the schools of amalgamating the higher standards for instruction under one teacher has been obviated, while the best qualified teacher of a subject on the staff gives instruction to all classes in that subject. Further, the organisation enables efficient instruction to be continued so long as the scholar is prepared to remain at the school, and already there are tangible signs that both scholars and parents are ready to take advantage of this and to prolong the school life. The subjects of the curriculum are:—

> Religious Instruction, English (including Composition, Grammar and Literature), Mathematics (Arithmetic, Algebra and Geometry), History, Geography, Drawing, Singing, and Physical Exercises: for boys—Science (Physics) theoretical and practical, and Handicraft (Woodwork): and for girls—Domestic Science—Needlework, Cookery and Laundry Work: with the addition of a Modern

Language (French) for more advanced scholars likely to remain for at least three years.

There are at present six Council Central Schools, three for Boys with an enrolment of 959, and three for Girls with an enrolment of 884, and one Non-Provided (R.C.) Central School for Boys with an enrolment of 365.

This re-organisation, with the provision of Secondary Schools, will supplant the Boys' Higher Elementary School which, for the past 18 years, has done admirable work in carrying boys, selected at 12 years of age from the schools throughout the town, through an advanced curriculum extending over three years, and it is the successful work of this school which in a large measure has led to the new re-organisation and extension of the school curriculum for the older scholars generally.

The Local Authority since its formation has given special care to the Religious Instruction in the Schools, and the syllabus adopted has repeatedly been commended. The work was examined annually and reported upon by special Inspectors, but for the past six years instead of an annual examination, the instruction given in the Schools has been inspected throughout the year and reported upon at the close of the Educational Year. The Authority has been glad to learn of the excellent and efficient manner in which this instruction is being steadily maintained in the Schools.

The subject of Thrift has continuously received attention, and its practical application has been encouraged by the establishment of Banks in each school associated with the Liverpool Savings Bank. During the past year £7,537 was deposited by scholars in the Council Schools, of which £1,280 was transferred to the Savings Bank in the Depositors' own names, and £2,236 was due to Depositors at the close of the year.

Interest in Music has been fostered by the establishment of School Choirs out of school hours, and the high standard reached is testified by one or other of the Choirs having each year gained high honours at a

Musical Festival, embracing a large portion of the County of Chester, which is held annually.

An efficient system of School Medical Inspection exists in connection with all the elementary schools and three of the secondary schools. The Medical Officer of Health acts as School Medical Officer, and in addition, there are two Assistant School Medical Officers and one Dental Surgeon. The work of the nursing staff is combined with that of the Public Health Service, the services thus rendered to the schools being equivalent to the full time services of six nurses Three clinics have been established for the treatment of necessitous cases in respect of minor ailments, teeth and eyes, and in addition, a cleansing station and an X-ray installation for the treatment of ringworm. This important work, of which full details are given in the annual report of the School Medical Officer, has already proved of inestimable benefit to the children throughout the schools.

Meals are provided for necessitous school children under the provisions of the Education Act, the meals being cooked at a Central Kitchen and served at five convenient distributing centres in various parts of the town. The total number of meals supplied during the past year was 204,311.

In addition to full provision for Physical Exercises in the schools, organised games out of school hours are arranged and conducted by a voluntary Committee of teachers: for girls—Rounders Teams are formed in two Leagues, which stimulate interest and rivalry: and for boys similar organisations are maintained for Cricket and Football. Instruction in Swimming is also organised and Certificates awarded to scholars who pass qualifying tests. A popular event has been an Annual Athletic Festival for all the Schools, which is attended in very large numbers by parents and friends.

The great extent of casual employment largely in connection with the docks, and the consequent migratory character of the population has called for unusual efforts in the matter of school attendance.

Notwithstanding these difficulties, the regularity of attendance has increased from a little over 50 per cent. at the time the first Education Act was passed to a percentage ranging from 83 to 88, during the past four years. The total number on the rolls is nearly 25,000.

Blind, Deaf and Epileptic children are placed in residential institutions outside the district, and children whose home surroundings or conduct are unsatisfactory are sent to Industrial Schools, one of which, the Albert Memorial Industrial School, is situated in Birkenhead. It was founded in 1864 by the philanthropy and generosity of residents in the district, and effectively provides industrial training for some 120 boys.

Provision for Mentally Defective children has been made in the Special Day School for Mentally Defective children, established by the Authority in 1903, with accommodation for 130 children, which is fully utilised. The after-care of these children on their leaving the school has been organised, and it has been ascertained that a very large proportion of the children are engaged in suitable occupations, many of them being self-supporting.

The Authority deplores the absence of any endowment for Elementary Education, in consequence of which all expenditure has to be defrayed from Public Funds.

The same lack of endowments has hampered the provision of Higher Education. The Secondary Schools of the Borough include two schools managed by the Education Committee, the Birkenhead Institute for Boys and the Council Secondary School for Girls.

The Institute was transferred to the Authority in 1908, having been founded in 1888, mainly through the exertions of the late Mr. George Atkin, J.P., as an Undenominational School to supply a liberal education at a moderate fee; it has a present enrolment, including a small Junior School, of 496 boys. The Secondary School for Girls was opened by the Authority in 1906, and the Junior Forms are at present accommodated in temporary premises; the school has

at present a total enrolment of 444. Provision has been made by the Authority for three further Secondary Schools (two for boys and one for girls) for a total of some 1,000 pupils.

In addition, there are two recognised Secondary Schools for girls whose finances are aided by the Education Committee, while two Roman Catholic Secondary Schools for boys in Liverpool, attended by Birkenhead scholars, receive aid from the Birkenhead Authority. The Oxton School of the Girls' Public Day School Trust and the Birkenhead School—a boys' school of Public School standing—do not receive aid from the Education Committee. There are also a considerable number of private Secondary Schools which have both boarders and day scholars. The total enrolment in the 'recognised' Schools is 1,371 pupils, and in the private schools some 750 pupils.

The Authority's Scheme of Scholarships and Maintenance Grants enables scholars to proceed from the Elementary to the Secondary Schools and from the Secondary Schools to the Universities, while Trust Scholarships, connected with two of the boys' schools, enables boys to enter the older Universities.

The School of Art, originally started in 1855, is now situated at the entrance to Birkenhead Park, in premises provided by the late Mr. John Laird, which were transferred to the Authority by the Trustees in 1892. Both day and evening classes are held and the instruction includes not only pure Art, but Woodcarving, Art Needlework and Embroidery, Painting and Decorating.

A very complete system of Evening Schools exists for the further education of young people in Preliminary Technical, Commercial, Domestic and Literary subjects, the work being organised in 'Grouped Courses' throughout. Technical Instruction is provided by the Authority's Holt Technical (Evening) School, at which Courses of Instruction extending over four or five years are organised in Technical and Science Subjects, including Mechanical Engineering, Electrical

Engineering, Naval Architecture, Building Trades, Chemistry: a staff of highly qualified lecturers is engaged, and the School is fully equipped with laboratories, workshops and apparatus. The number attending the Evening Schools is over 3,000.

The Theological College of St. Aidan was opened in Birkenhead in 1847 for the training of candidates for Holy Orders for the Church of England. The College is affiliated to the Liverpool University and is attended by students from a wide area, being the only such Theological College in this part of the country.

The Authority have, since 1913, exercised their powers under the Education (Choice of Employment) Act of 1910. A juvenile Employment Bureau gives suitable information and advice with regard to the choice of employment to boys and girls, and, as far as possible, the work and further education of young people is supervised until they have reached the age of eighteen years. The exceptional amount of unemployment now existing among these young people has led the Authority to establish Day Centres for the instruction of some 250 boys and 150 girls.

The expenditure of the Local Education Authority during the past year amounted to £302,000, of which sum £170,000 was derived from Government Grants and Miscellaneous Income, and £132,000 from rates, being equivalent to a rate of 3s. 3d. in the £.

The County Borough of Wallasey occupies the extreme North-east corner of the Wirral Peninsula. It is a popular seaside place with an exceptional record as a health resort, and is almost entirely a residential area.

The population has grown very rapidly during quite recent years. From 33,000 in 1891, it rose to 54,000 in 1901, and it is now about 90,000. The principal occupations of its inhabitants are commercial and professional, pursued mainly in Liverpool, and the various industries are concentrated in the south end near the docks of Birkenhead. The Borough is divided into two distinct areas, commercial in the North and

East, industrial in the South and West, and each of these divisions is fairly homogeneous. This, of course, has a distinct bearing upon the educational problem of the Borough.

To keep pace with the educational requirements of a population increasing so rapidly has been a somewhat strenuous task. The system is for the most part modern, and most of the buildings are comparatively new.

Without detailing the earlier history of the educational system, we may note that in 1900, shortly before the Education Committee took over the administration of education within the Borough, there were 8,341 children in the elementary schools of Wallasey, of whom 5,511 were in the Voluntary or Non-provided schools. The then newly-created School Board had two large schools attended by 2,831 scholars. The National Society had eight schools with 3,522 scholars; the Roman Catholics had three with 1,051 scholars; the Wesleyans one with 606; and the British Society one with 331 children in attendance. Since that time, five new Council Schools have been built, and the present accommodation of the Elementary Schools is over 11,000, whilst the number on roll is approximately equal to the accommodation. Before the war the Local Authority adopted the policy of small classes, aiming at a maximum of 40 for Senior Classes and 48 for Infants. This was practically realised. In 1904, the average size of the classes was 52.6. In 1919, there were 273 classes in the Elementary Schools, in charge of 315 teachers, and the average number of scholars per teacher was 37.5. The further development of this policy is now held up by the present restrictions of the Board of Education, but it will be resumed as soon as possible. The teaching staff is well qualified, consisting as it does of 172 trained certificated, 93 certificated, 47 uncertificated, and three supplementary teachers.

Special attention is given to Practical Instruction in all schools. The new Council Schools have manual instruction rooms, cookery rooms and science

laboratories, and fully qualified specialist teachers are engaged for the teaching of these subjects. Scholars from the Non-provided schools attend the centres in rota. Three of these schools have been provided with wireless apparatus, partly made and installed by the scholars themselves. A house is rented as a housewifery centre for combined domestic subjects, and here the girls complete their domestic training after passing through the ordinary two year courses at school.

There are six Attendance Officers in charge of a Senior Officer. During the last year 34,020 visits were made in respect of 39,260 children, and the percentage of attendance was 87.1. A census of the child population of the Borough was completed in 1920, after two years' work, and one day per week is given by the Officers to census work, in order to keep the records up-to-date. The School Attendance Department has charge also of Street Trading, and the issuing of licenses to school children for daily work.

The Central Schools were opened, as Higher Elementary Schools, in 1908. They have accommodation for 300 boys and 300 girls. These are taken by competitive examination from the Elementary Schools, about 70 scholars of each sex being admitted each year. They enter for a four years' course, including a foreign language, French for the Girls, and Spanish for the Boys. The scholars are entered for the School Certificate Examination of the Northern Universities, and have been remarkably successful in this work. The staff consists of well-qualified specialist teachers, many of whom are University Graduates.

The School Medical Service staff consists of the School Medical Officer, Assistant S.M.O., School Dentist, two Visiting Nurses and two Assistants. A School Clinic system has been established and special clinics are regularly held for the treatment of minor ailments, tonsils and adenoids, defective vision, orthopædic cases, etc.

A Special School for physically defective children has been established at Lucerne Road. Since 1920, classes

for remedial treatment of stammerers have been held in the Central Park. There are three classes, each meeting twice per week. Each class numbers about 12 pupils, and the work is in charge of a specially qualified teacher. Since 1920, 84 children have been treated with very satisfactory results. There are now under treatment 24 boys and 13 girls, and during the past year seven boys and five girls were discharged as cured.

A Special Class for dull and backward children has been formed for experimental teaching. Children who are not mentally defective, but who are so backward that they cannot benefit by instruction in the Elementary Schools, are sent to the Special Class for treatment, and are restored to their old schools when they have made sufficient progress. This class is limited to 20 children, and is in charge of a Special School Teacher.

Abundant provision is made for physical training and organised games. The Sports' Associations, formed by the teachers, arrange matches and games of cricket, football, hockey, rounders, and lessons in swimming. Organised games are held during school hours under competent supervision, and are recognised as part of the regular curriculum of the schools. The Parks Committee grant the use of playing fields in the public parks. The use of the Riverside Baths during school hours has made possible the organisation of swimming instruction for both boys and girls, and full advantage is taken of this arrangement. The Education Committee make grants to the various Associations for the purchase of the necessary apparatus.

No local Centres are maintained for Blind, Deaf or Epileptic children, but those suffering from these disabilities are sent to suitable institutions. Thus five blind children attend Certified Schools in Liverpool: ten deaf children attend the Certified School in Oxford Street, Liverpool; and one epileptic child attends the Certified School at Maghull.

The Juvenile Employment Bureau was established in 1912, in accordance with the Scheme for the exercise of

the powers of the Local Authority under the Choice of Employment Act, 1910. The Bureau, in conjunction with the Ministry of Labour, carries out the requirements of the Unemployment Insurance Act of 1921, and when the Local Education Authority takes over the administration of the Unemployment Insurance Act, 1923, it will be entirely responsible for this work. The work of the Bureau is conducted jointly by the Juvenile Employment Officer appointed by the Education Committee, and the Co-operating Officer of the Ministry of Labour. Applicants registering at the Bureau are between the ages of 14 and 18—after that age they are transferred to the Adult Exchange.

Wallasey is well provided with facilities for Higher Education. There are four large public Secondary Schools in the Borough, all under the management of the Authority. The Grammar School is an old foundation School, dating back to the 16th century. The present building, erected in 1910, stands in six acres of ground, most of which is used for playing fields. The building contains 20 classrooms, with accommodation nominally for 540 boys. There are at present 600 boys on the roll. The High School for Girls was opened in 1909. It has tennis courts and playgrounds in the rear of the school and a hockey field near by. It provides accommodation nominally for 420 girls, but the number actually enrolled at the present time is 560. The Oldershaw Municipal Secondary Schools were opened in 1920, and accommodate 360 boys and 360 girls. The schools are free, admission being awarded on the results of the annual School Examination referred to below.

The present provision of Secondary School places is more than 20 per 1,000 of the population, but this, satisfactory though it is, does not meet the local demand for Secondary Education, as the figures given shew. The Local Authority proposed to extend the Oldershaw Schools so as to raise the accommodation to about 1,000, but the Board of Education have not yet found themselves able to sanction the proposal. For

the present, therefore, further development in this direction is suspended.

In order to link up the Elementary and Secondary Schools more closely, an Annual School Examination was established in 1920. All scholars between the ages of 11 and 12, in Primary Schools, and also in the Junior Departments of the Secondary Schools, are required to take the examination unless there are special reasons against it. Pupils from Private Schools who wish to attend the Secondary Schools must also take this examination. The main features of this Scheme will be laid before the Education Section this year in the paper to be read by the Director of Education for Wallasey.

In addition to the Free Places granted annually on the results of the annual School Examination, the Committee award Junior Scholarships by competition to fee-paying pupils in the Grammar School and High School. They have also established a system of Maintenance Grants to enable students in Secondary Schools to take 'Advanced Courses.' There are also two Borough University Scholarships, first awarded in 1899. The Trustees of the late Robert Davies have founded at Emmanuel College, Cambridge, three scholarships open to candidates who have resided for the last three years at least in the Parliamentary Division of Wallasey. The first of these scholarships was awarded last December to Alan H. Wilson, of the Wallasey Grammar School.

The Wallasey Technical Classes were established in 1903. There are now four large centres for Commercial and Literary Subjects, two for Technical and Engineering Classes, two for Woodwork, and two for Cookery and Dressmaking. The schools are closely connected with the Union of Lancashire and Cheshire Institutes, and the students are also prepared for the examinations of the Royal Society of Arts and of the City and Guilds of London Institute. Last year 98 separate classes were held, attended by 2,670 students.

The Evening Schools are closely connected with the

Elementary Schools by a system of Free Places. At the end of each school year the Head Teachers nominate children leaving school for a free studentship in the Evening Schools, and care is taken to see that as many as possible of these children enrol at the beginning of the next session.

The School of Art was established many years ago, and in 1897 was transferred to its present premises in the Central Park. The School is well-equipped, and provides instruction for Designers, Draughtsmen, Engravers, Painters, Modellers and other Art Workers occupied in industry, as well as for Artists, Sculptors and Art Teachers, whilst Special Classes for teachers in Elementary and Secondary schools form an important branch of its work.

The Scheme for the future development of education in Wallasey was completed in January, 1920, in accordance with the Act of 1918. It was approved by the Board of Education in April, 1921, with the suspensive restrictions of Circular 1190, of January, 1921. It provides for the establishment of Day Continuation Schools, and Open Air Schools, for the erection of two new Central Schools and for the remodelling and improvement of the older schools. It also provides for a considerable extension of the existing system of Secondary and Higher Education. The practical realisation of these proposals depends only on the return of suitable financial conditions in local and central government.

Bootle is a town of some 80,000 inhabitants, which lies on the East bank of the Mersey to the North of Liverpool, with which it is, in fact, practically continuous. Like Wallasey, its growth has taken place almost entirely within the nineteenth century, at the commencement of which it consisted of a hamlet with about 600 residents. By 1869, the population had increased sufficiently for a charter of incorporation to be granted, and the town became a County Borough in 1888. A School Board was formed in 1870, one of the

earliest in the provinces, and the Bye-laws framed by this Board were, in point of time, the second in the country to be approved.

Employment in connection with shipping constitutes the main occupation of the town, and the population consequently includes a very large proportion of unskilled labour. The area contains also some large railway depots, warehouses, dyeworks, tanneries, engineering works, ship-repairing works and timber yards.

The Elementary School provision consists of seven Council and six Non-provided Schools, with 11,414 children in average attendance; 6,424 of these attend the Council Schools and 4,990 the Non-provided Schools. There are three centres for Woodwork instruction, and three for Cookery and Laundry work. Advanced instruction is provided by means of Central Classes at certain schools. There is also an Art Centre at which selected scholars from the Elementary and Secondary Schools attend each week to receive special instruction.

Bootle claims to have been one of the first Authorities in the country to have worked out a scheme of co-operation between the Public Libraries and the Schools, this scheme having been inaugurated in 1894. At the present time each school in the Borough serves as a 'delivery centre' for the Library, and the issue of books through these centres for the year ended 31st March, 1922, amounted to 55,222.

The School Medical work includes the maintenance of clinics for eyes, ears, throats and minor ailments, also a dental clinic. Remedial gymnastic exercises are given under the direction of an orthopædic surgeon. As elsewhere on Merseyside, every encouragement is given by the Authority to school sports, including swimming, and there is close co-operation between the schools and social organisations for young people, such as Boys' and Girls' clubs. Three Evening Play Centres were opened in 1919. A Children's Musical Festival is held annually, arrangements for which are carried

out by an enthusiastic Committee of the local Teachers' Association. Musical items prepared for the Festival are taken in most of the schools as part of the school's curriculum, and it is recognised that by such means a love of good music in inculcated and a refining influence fostered.

In all the Council Schools, and in two Voluntary Schools, Penny Savings Banks have been established and are affiliated to the Liverpool Penny Savings Bank Association. This practical means of inculcating thrift at the most impressionable age has been carried on with remarkable success for many years. Some idea of the work involved may be gathered from the fact that during 1922 in the Council Schools there were 94,369 separate deposits, 10,624 repayments, and 431 transfers, a total of 105,424 transactions. During the War most of the schools became centres for the issue of War Savings Certificates, and great success attended the efforts of the teachers. One school has disposed of Savings Certificates for £20,000 and another for £16,000.

The Secondary Schools for Boys and Girls, respectively, have been provided by the Borough Council, and are maintained by them. They accommodate 450 boys and 340 girls, respectively, but further Secondary School accommodation is projected which will allow of the admission of 500 boys and 450 girls in all.

Technical Education began in the Borough in 1888, and in 1891 Bootle was the first town in England to apply the 'whiskey money' to its development. The Municipal Technical School was opened in 1900, and provides for about 1,000 students: the school organisation includes a full-time Junior Technical Day School for 150 boys. There is also a central Evening Continuation School.

Scholarships tenable at Universities are available for students from the Secondary Schools and the Technical School: some of these are provided by the Authority and others are due to the munificence of private

donors. Among the latter those founded by Lord Derby and by Councillor Pennington in commemoration of the signing of peace after the European War of 1914-1918, and those subsequently founded by Mr. C. Tyerman Taylor, may be specially mentioned.

The expenditure on education during the last year amounted to £164,000. Government Grants, etc., amounted to £87,000, and the sum of £77,000 was received from local rates, being equivalent to a rate of 2s. 10½d. in the £.

WALKER ART GALLERY.

ARTHUR G. QUIGLEY,
CURATOR, ART GALLERY.

THE Gallery, which bears his name, was built by the late Sir Andrew Barclay Walker, Bart., through whose munificence this splendid building came into the possession of the Liverpool Corporation. The Foundation Stone was laid in 1874 by H.R.H. the Duke of Edinburgh, the Archbishop of York taking part in the ceremony, and the completed Gallery was first opened to the public in 1877. Those who knew Liverpool in the seventies can recall the great ceremony which accompanied that opening—an acknowledgment in itself of the significance of the undertaking by a municipal body. At a period when elegant buildings in Liverpool were conspicuous by their absence, a gift of this nature was eloquent testimony of a prophetic insight into things to come.

The need for an Art Gallery may have been emphasised by the success of the Autumn Exhibitions, begun under Corporation auspices in 1871, or as the natural outcome of art movements which had their genesis in the town a century earlier. There does not appear to have been any art institution in Liverpool prior to the year 1769, about which date efforts were made to create one. The first Society formed had but a year's existence; a second lived for two years; and a third—supported by such men as Mr. Henry Blundell, of Ince Blundell, and Mr. William Roscoe—held three exhibitions, one of which included works by Sir Joshua

Reynolds, Paul Sandby, Thomas Stothard, Angelica Kauffman, and other eminent artists of the day; then, after a few years, this Society appears to have become extinct. In 1810, however, with the formation of the Liverpool Academy, came a new and enduring effort. The Academy promoted exhibitions and made a great reputation, but its crowning effort, no doubt, was the institution of an annual prize of £50 for the most meritorious picture exhibited by a non-resident artist "as a means of inducing artists of eminence to contribute"—an endeavour, it is said, which, while giving to the Academy its chief claim to immortality, was the indirect cause of its downfall. From 1830 to 1862 (with one exception) this award was made, and it is interesting to note the Academy's recognition of the work of the Pre-Raphaelites and the encouragement given to that Brotherhood in its struggling days, when in London it received abuse. Time, which has confirmed the judgment of the Academy, has also witnessed the decline of its glory, brought about by dissension among its members, and disapproval in other directions. Antagonism on the part of members towards an award given to Millais' "Blind Girl" in 1857 caused a breach which resulted in the formation of a rival body, called the Liverpool Society of Fine Arts. The conflict between this Society and its parent lessened the now divided patronage, and the resultant ill-effects to each prompted an attempt at reconciliation by means of a joint exhibition under a reconstituted body. This was not wholly satisfactory, and a second attempt at fusion was made in the shape of another joint exhibition. The new society ultimately passed out of existence, leaving the old one still in the field; not, however, without being maimed both in patronage and finance—the subsidy amounting to £200 a year, granted by the Corporation since 1830, being withdrawn.

The Academy held one further exhibition in 1867, and, apparently exhausted by the conflict, withdrew from the ambitious pursuit of public exhibitions.

Doubtless, the absence of these disclosed a public want, and was the reason for the Corporation stepping into the breach by instituting exhibitions of their own: thus, the first municipal Autumn Exhibition in 1871 was held in the Public Museums, and repeated there annually until 1876, after which the Exhibitions were transferred to the then new Walker Art Gallery, where they were continued in unbroken sequence until 1917. From that year until 1919, however, they were suspended owing to the War and the occupation of the Gallery by the Government for other purposes. The Exhibitions were revived in 1919, and the Jubilee was celebrated last year.

It is noteworthy that in the financial success of these exhibitions lies the germ from which the Permanent Collection has grown, and is still the chief source from which it expands; the City Council devoting each Exhibition's surplus receipts over expenditure to the acquisition of new works, the total catalogue value of which, at the present time, is estimated at about £85,000 (including purchases under the bequest of the 15th Earl of Derby of a capital sum, the interest of which is applied to the acquisition of pictures by rising artists). Add to this acquisitions by gift and bequest, and the total collection reaches an estimated value of £150,000.

The first portion of the building comprised six rooms and vestibule on the ground floor, with eight rooms and vestibule on the upper floor; but, this space proving inadequate, an extension was built by the Corporation in 1884 of six rooms—one on the ground floor and five on the upper floor. On the completion of the extension, however, the whole of the additional cost was defrayed by Sir Andrew Barclay Walker.

When the Gallery was erected, the pictures belonging to the Corporation consisted of about one hundred, hung in various buildings. These works were transferred to the Walker Art Gallery, and formed the nucleus of the present Permanent Collection, now

approaching 2,000 works in oils, watercolours, sculpture, and black and white, besides reproductions of Italian, Flemish, Primitives, and Early English Painters.

In addition there are 213 works, mainly from the collection of William Roscoe, deposited by the Trustees of the Liverpool Royal Institution; 31 paintings deposited by Sir Neville Cunliffe, Bart.; 9 lent by the Trustees of the National Gallery; and other paintings by Oswald Birley, A. W. Hunt, Millais, Nicolo del'Abati, Raeburn, Romney, etc., lent by their various owners.

The Roscoe Collection, though small, is unique, illustrating in outline the history and progress of ancient art from the thirteenth to the nineteenth centuries, notably by examples of Byzantine painting; a remarkably good panel by Simone di Martino; examples by Catena; Giovanni, Gentile, and Jacopo Bellini; Giorgione; Jacopo da Ponte; Tintoretto, etc. Amongst the painters of the Netherlands are Peter Breughel, Ferdinand Bol, Lucas Cranach, Berchem, Hondecoeter, Lucas van Leiden, Roger van der Weyden, Michael Wolgemuth, etc.

The Cunliffe Collection consists of portraits by James Cranke ('Old Cranke'), Francis Cotes, Hoppner, and Nicolas Maes; landscapes by Richard Wilson, Hobbema, Van Goyen, Wynants and Wyntracht, Pynaker; and interior subjects by De Lys, Zorg, etc.

The general collection contains examples of the earlier masters, but is for the most part of a modern contemporary character, including world-famed paintings by members of the Pre-Raphaelite Brotherhood, viz.:—Millais, 'Lorenzo and Isabella'; Holman Hunt, 'Triumph of the Innocents'; and Rossetti, 'Dante's Dream'; also works by artists who sympathized with or came under the influence of that group, e.g., Ford Madox Brown, 'The Coat of Many Colours'; John Brett, 'The Stonebreaker,'; Arthur Hughes, 'Scenes from "As you like it"'; Sir E. Burne-Jones, 'Sponsa di Libano'; and W. Shakespeare

Burton, 'Auto da Fé.' The art of G. F. Watts* is shewn by four examples, 'Promises,' 'Cupid Asleep,' 'Naples,' and 'The Court of Death,' the last named, painted in 1881, probably being the study for the large version in the National Gallery of British Art.

Other artists of distinction included are:—E. A. Abbey, Edgar Bundy, D. Y. Cameron, W. P. Frith, M. Greiffenhagen, Arthur Hacker, Sir Hubert von Herkomer, Alphonse Legros, Sir John Lavery, Lord Leighton, Sir David Murray, William Nicholson, Sir W. Q. Orchardson, Julius Olsson, James Paterson, Sir W. B. Richmond, Sir J. J. Shannon, Giovanni Segantini, William Stott (of Oldham), Solomon J. Solomon, Mrs. Swynnerton, Sir H. Hughes-Stanton, etc.

The watercolour section is composed of work by early and modern aquarellists, viz.:—Barret, Cox, Cotman, Farington, W. Hunt, Prout, Sandby, Turner, Thirtle, Varley, Sir L. Alma-Tadema, Mrs. Allingham, R. Anning Bell, Frank Brangwyn, James Cadenhead, Birket Foster, W. Russell Flint, Francis James, Arthur Melville, A. W. Rich, Charles Sims, etc.

The Black and White Collection comprises original drawings, etchings, mezzotints, and lithographs by R. Anning Bell, Muirhead Bone, Ford Madox Brown, Francis Dodd, D. Y. Cameron, Sir F. Seymour-Haden, W. Holman Hunt, D. G. Rossetti, Sir Frank Short, Frederick Sandys, J. M. W. Turner (Liber Studiorum), J. McNeil Whistler, Anders Zorn, and other leading artists in this medium.

The collection of sculpture contains interesting works

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*Since the above was written, the Permanent Collection has been enriched through the generous bequest by Mr. James Smith, of Blundellsands, of practically the whole of his remarkable collection. The portion which comes to the Gallery immediately, consists of:—

18 Paintings by G. F. Watts,
3 „ „ W. L. Windus,
6 „ „ D. A. Williamson,
3 „ „ A. Monticelli,
100 Watercolours by D. A. Williamson,
4 works in Sculpture by A. Rodin,

And various Etchings and Engravings by Albrecht Dürer, Sir Seymour Haden, and Samuel Palmer.

These works are now on view in the Galleries.

by Chas. J. Allen, Harry Bates, E. Onslow Ford, Alfred Gilbert, Alfred Drury, Conrad Dressler, Sir George Frampton, Lord Leighton, F. W. Pomeroy, Sir W. Hamo Thorneycroft, and Albert Toft.

A special feature in the Galleries is the arrangement of the work of the Liverpool School from its beginning. Though not yet wholly representative, there is ample material on view to shew the trend of art in our city. Among the earlier men are pictures by Richard Ansdell, W. J. Bishop, W. J. J. C. Bond, James Campbell, William Daniels, William Davis, Henry Dawson, S. Eglington, Thomas Hargreaves, William Huggins, George Lance, Alexander Mosses, J. W. Oakes, R. P. Richards, John Robertson, George Stubbs, Robert Tonge, Charles Towne, D. A. Williamson, W. L. Windus. Later artists represented are W. B. Boadle, F. T. Copnall, J. Y. Dawbarn, John Finnie, Robert Fowler, Peter Ghent, J. Hamilton Hay, Thomas Huson, David C. Jenkins, Miss Mary McCrossan, R. E. Morrison, W. Alison Martin, G. Hall Neale, H. B. Roberts, Herbert Royle, Harold Swanwick, etc.

The water colourists, who have brought distinction to Liverpool in this medium, are represented by S. Austin, Charles Barber, William Collingwood, A. W. Hunt, H. C. Pidgeon, H. B. Roberts, William Eden, A. E. Brockbank, George Brown, S. J. M. Brown, George Cockram, Isaac Cooke, W. Follen Bishop, W. G. Herdman, Harry Hime, J. Clinton Jones, T. Hampson Jones, W. L. Kerry, John McDougal, John Pedder, James T. Watts, and D. A. Williamson.

The vigorous development of the Permanent Collection since the establishment of the Gallery has gained for Liverpool a foremost place in the art world, and in this the City Council cannot fail to recognise its deep obligation to all those generous donors, who have not only enriched the collection to an inestimable extent, and provided means for the extension of the building, but have identified themselves for all time with the highest aims of the community.

The Gallery is controlled by the Libraries, Museums and Arts Committee of the City Council, under the Chairmanship of Councillor Henry A. Cole, and the working of the Institution is placed in charge of the Art and Exhibitions Sub-Committee, under the Chairmanship of Alderman John Lea, who has the valuable co-operation of the Right Hon. Lord Wavertree (son of Sir Andrew Barclay Walker) as Deputy-Chairman; also of the President of the Liverpool Academy of Arts as Advisory Member.

THE PUBLIC MUSEUMS OF LIVERPOOL.

Joseph A. Clubb, D.Sc.,
Curator of Museums.

The Public Museum movement is Liverpool was contemporary with that for Public Libraries. In 1850 a Committee was appointed by the Town Council and negotiations were opened with the Trustees of the Royal Institution, Liverpool, and recommendations made that an Act of Parliament be obtained for the transfer of the Royal Institution and its contents (paintings, casts, natural history collections, books, etc.) to the Corporation, and that a Public Library, Museum and Gallery of Art be established in the building in Colquitt Street. Accordingly, the 'Liverpool Royal Institution (Transfer of Property) Bill' was submitted to Parliament in the following year, but was later withdrawn. Valuable support was accorded to the movement by an association of citizens which was formed towards the end of the year to promote the formation of the proposed Library, Museum and Gallery of Art and to solicit subscriptions, books and specimens.

History of the Museum Buildings. In September, 1851, the purchase of the Union Newsroom, Duke Street, for the purpose of a Free Library and Museum was decided upon. This building served as a temporary resting place for a period of nine years. In the year 1856 Mr. William Brown, a leading merchant of Liverpool and Member of Parliament for the town, offered to erect a new Public Library and Museum on Shaw's Brow. This offer was gratefully accepted by the Corporation, who provided the site, and the foundation stone was laid by the donor on the 15th April, 1857.

It was formally opened to the public by Mr. William Brown (afterwards Sir William Brown, Bart.) on the

18th October, 1860. The Main Hall and West Wing of the building were allocated for Museum purposes. An important addition was made to the exhibition space a few years later, by roofing in an area contained between the walls of the existing building and by the provision of two galleries running around it. For over thirty years this building sufficed for the accommodation of the Museum collections, but by about 1895 the congestion became so great that an extension became necessary. In the year 1898 the foundation stone of the Museums Extension Buildings and Technical School was laid by Sir William Bower Forwood, D.L., J.P., Chairman of the Library, Museum and Arts Committee, and the New Museum Galleries were opened to the public by the Right Hon. Frederick Arthur, 16th Earl of Derby, in 1906. These galleries, two in number, extend over the Technical School, and by this addition the floor area for exhibition purposes was practically doubled. The total area of the exhibition galleries in the existing Museums Buildings is over 64,000 square feet, approximately 1½ acres. In addition, by the use of basements and conversion of roof spaces, laboratories, workrooms and galleries to house extensive study collections are also contained.

History of the Collections.—The City of Liverpool has been particularly fortunate in the number and importance of the large collections that have been bequeathed and given to the Public Museums. These have been added to by generous action on the part of the City Council in the purchase from time to time of collections to augment and supplement the series. Two outstanding gifts to the City were received early in the Museum development, for in the year 1851 the collection of Natural History, formed by the Right Hon. Edward-Smith, 13th Earl of Derby, K.G., F.Z.S., was bequeathed to the town, and in the year 1867 the large and important collections of Archæology, made by Mr. Joseph Mayer, F.S.A., a worthy Liverpool citizen, were presented by him. These collections formed the

nuclei of the two Museums, now comprising the Public Museums of Liverpool—The Lord Derby Museum of Natural History and the Mayer Museum of Archæology and Ethnography.

The Lord Derby collections contained some thousands of specimens, mainly Mammals and Birds. In addition to many type species, the Birds included several collections of historical interest, viz., the birds collected by Sir Joseph Hooker on the Ross Antarctic Expedition, 1839-41, birds collected in Arctic America by the Franklin Search Expedition in the S.S. 'Fox,' 1857, and birds collected in the Sandwich Islands, some of them on Captain Cook's great voyages.

The Mayer collection has a world-wide reputation, due to the many important and often unique objects contained therein. It is especially rich in Egyptian and early Roman antiquities, mediæval ivories, enamels, glass and illuminated manuscripts; in very important pottery collections (both British and European), conspicuous for the wealth of Wedgwood and Old Liverpool wares and in the very important and unrivalled collection of Anglo-Saxon antiquities made by the Rev. Bryan Faussett from graves in Kent.

Exigencies of space prevent me from dealing in detail with many other important donations made to the City Museum, but the following, arranged chronologically, deserve recording.

In 1871 a bequest by Mr. John Mather of a collection of Miniatures, etc., relating to the Bonaparte family.

In 1877 the Rutter-Phillips collection of Minerals presented by the Liverpool Medical Institution.

In 1885 bequest of the Nicholas Cooke collection of British Lepidoptera.

In 1887 a collection of skins and horns of large game animals, presented by Mr. St. George Littledale.

In 1893 bequest by the Right Hon. Edward Henry, 15th Earl of Derby, K.G., of a collection of polished agates, etc.

In 1894 a collection of West African Ethnographical objects by Mr. A. Ridyard, Chief Engineer, Messrs. Elder, Dempster & Co., Liverpool, which, for twenty years Mr. Ridyard continued to augment by presenting specimens of ethnology from the West African districts. The Museums Committee recognised their indebtedness to Mr. Ridyard on his retirement by presenting him with an address and naming the section the 'Ridyard' Collection of African Ethnology, which is probably the finest in the country.

In 1901 a large and important collection of shells from all parts of the world, bequeathed by Mrs. Mary MacIver.

In 1917 a cabinet of Coleoptera (mainly local) and a local herbarium, made and arranged by Lieut.-Colonel John W. Ellis, M.B., F.E.S., presented by the Liverpool Naturalists Field Club, and a cabinet of Brazilian Insects collected by a former Mayor of Liverpool, Mr. John Bramley-Moore, and presented by his son, the Rev. William Bramley-Moore.

In 1918 the collection of Fossil Footprints from the Trias, collected mainly in the local area by Mr. H. C. Beasley, presented by Councillor Sydney Jones.

Of the many important additions to the collections made by purchase the following deserve special mention:—The Austin Collection of Carboniferous and other Crinoids, so well known to palaeontologists, purchased in 1886, and the Tristram Collection of Birds, consisting of over 6,000 species, belonging to all Orders (of which 150 are types), and 20,000 specimens, purchased in 1896.

On three occasions the Museum authorities have actively participated in expeditions to foreign countries for the purpose of collecting specimens for the Museums. In the year 1876, on the invitation of Mr. R. Cholmondelay, of Condover Hall, Salop, the Chairman of the Museums Sub-Committee (Rev. H. H. Higgins), accompanied by two assistants, took part in an expedition to the West Indies on the Steam Yacht

'Argo,' for the purpose especially of collecting marine specimens of Natural History. In 1898 the Committee agreed to co-operation with the British Museum (Nat. Hist.) in an expedition to the island of Socotra for the purpose of collecting specimens of the flora and fauna and of an ethnological character, in which the Director and an assistant took part. In 1913-14, on the invitation of the Director of the Malay States Museums, the Committee agreed to a six months' visit to Malaysia of one of the Museums assistants to collect specimens for the Museums. From each of these expeditions large and important accessions were made. The collections generally have grown to very large dimensions, and are probably larger than in any museum in Great Britain outside London.

The Collections and Arrangement at the Present Time. *The Lord Derby Natural History Museum* comprises departments of Zoology, Botany, Geology and Mineralogy. The exhibited collections are arranged on a popular but thoroughly scientific and educational basis and there are a number of very important study collections containing many type species. Special efforts have been made to form British (especially local) collections and the natural history of the neighbourhood is well represented both in the exhibition and study series. In British Mammals and Birds 'habitat' groups are largely made use of, and it is interesting to note here that the Liverpool Museum was very early, if not the earliest museum to adopt this class of exhibit, as there is a record in the Report of the British Association for 1865 that a 'habitat' group of the 'Coot' from the Liverpool Museum was exhibited at that meeting.

The Systematic General Zoological Gallery contains typical representatives only of all the leading groups, arranged from simple unicellular Protozoa to the highest Mammals terminating in the races of mankind. In addition to the exhibition of typical species, a feature

is made of a series of what may be called introductory cases, where specimens and dissections are shown to demonstrate the salient characters of the Orders.

The British Zoological Gallery contains representatives of all British specimens—local species being specially noted. The Mammals and Birds are exhibited in the 'habitat' groups above referred to, all the work on which is done by the Museum staff.

The British Botanical Gallery contains many local species both as herbarium and fluid preparations. In addition, a series of large models illustrating the Natural Orders is shown.

The British Palaeontological Gallery illustrates the stratigraphical sequence of fossils from the oldest to the recent formations. Much local material is incorporated into these series, including a number of Carboniferous Fossils from the Ravenhead cutting, near St. Helens, and Fossil Foot-prints from local Triassic rocks.

The Geological and Mineralogical Gallery contains a typical series of minerals and rocks. The minerals are arranged in groups according to their chemical composition. Special cases introductory to the study of Geology and Palaeontology have been prepared.

The Study Collections, which are available for all students and special workers, are as follows:—

Mammal Collection, very largely composed of specimens from the original Derby Bequest, with some type species.

Bird Collection, containing upwards of 50,000 specimens and including about 200 type species and the collections of historic interest contained in the Derby Bequest.

The 'Wallace' (Loan) Collection of British Birds' Eggs.

The 'Bramley-Moore' Collection of Brazilian Insects (mainly Coleoptera), 4,500 specimens.

The 'Cooke' Collection of British Lepidoptera, 24,000 specimens.

The 'Sharpe' Collection of British Coleoptera (many local), 50,000 specimens.

The 'Ellis' Collection of British Coleoptera, 17,000 specimens.

The 'Ellis' Herbarium (mainly local).

The 'Ellis' Collection of Mosses.

The 'Palgrave' Collection of Mosses.

The 'Beasley' Collection of Fossil Footprints from Trias (mainly local).

The "Austin" Collection of Fossil Crinoids.

The 'Rutter-Phillips' Collection of Minerals. This collection formed the material upon which the important work on Mineralogy by William Phillips, F.Z.S., M.G.S., published in 1823, was based.

An *Aquarium*, containing fresh and salt-water Animals, Amphibia and Reptiles, is situated in the basement.

The Mayer Museum of Archaeology and Ethnography comprises many sections, and large accessions have been made to the collections contained in the original gift by Mr. Joseph Mayer, and, in addition, large and important Ethnological collections, representative of most countries in the world, have been acquired.

In the *Egyptian Gallery* the various phases of Egyptian Art are well illustrated. Of the eighteenth dynasty there are some beautifully-executed figures, and the wooden figure of a slave carrying the 'stibium,' or antimony pot, is a beautiful example of wood-carving out of the solid. One of the most perfect examples of mummy wrapping (some thirteen layers are used in the process) is seen in the mummy of a child, bearing a painted portrait in which the vehicle for the colour is wax.

Collections (some of them loan collections) illustrating the early *Mediterranean Civilisations* embrace original pieces and replicas in plaster and metal of Cretan antiquities, examples of pottery and sculpture from Meroë in the Egyptian Soudan, and an important series of replicas of Hittite sculptures from Asia Minor forming at present the most complete series of Hittite Monuments on exhibition in the British Islands. *Romano-British* remains are also well represented.

The Gallery of *Anglo-Saxon* antiquities, mainly composed of the collections made from the Kentish Cemeteries by the Rev. Brian Faussett, contains many remarkable specimens, especially the numerous fibulae of various designs in gold and bronze, frequently combined with delicate inlaid work. Of these possibly the most beautiful example of Anglo-Saxon work in existence is the 'Kingston Brooch' found in one of these Kentish Tombs in 1771.

The series of early *Egyptian*, *Etruscan*, *Greek and Roman Ivory Carvings* are equally worthy of mention --the several Consular and Mythological Diptycha are of unique importance.

The Collection of *Byzantine and Gothic Ivories* is large, embracing all phases of the sculptor's art from the eleventh to the seventeenth century.

In the gallery devoted to the work of the Caucasian races is a collection of *Mediæval* and other antiquities. The *Mediæval Manuscripts* are of interest and importance there being a psalter of the twelfth century. Of *Enamels* there are examples in the form of book-covers, reliquaries, etc., of the eleventh to the thirteenth century, mostly executed at Limoges in France.

The collection of *English and Continental Ceramics* is extensive, and there are several important loan collections, notably of *Chinese and Japanese Imari Porcelain* of the seventeenth and eighteenth centuries, and a very fine collection of Delft Ware plates.

Among the collections illustrative of the Yellow Races are a rare and valuable Mexican Codex and some remarkable potted vessels of large size from the Upper Amazon.

A special feature has been made of a gallery devoted exclusively to the exhibition of specimens illustrative of the *History of Liverpool*. Prominent among these is the very extensive collection of ceramics, the products of the numerous *Liverpool Potteries*, which flourished from the early eighteenth to the nineteenth century. There are many pieces of great value, and this collection emphasises the importance and scope of the potter's industry in the town.

This brief summary of the Archaeological sections shows prominently the very wide field covered by the collections, and each section contains many treasures which only the specialist can appreciate at their full value.

THE LIVERPOOL PUBLIC LIBRARIES.

George T. Shaw,
Chief Librarian, Liverpool Public Libraries.

Liverpool possesses a large and efficient Public Library service. The first Public Library was established under a private Act of Parliament, and opened in 1852.

Starting with a Reference Library in temporary premises, the service has grown with the City, and to-day, in addition to the group of buildings in William Brown Street, there are fifteen (15) Branch Libraries and Reading Rooms scattered throughout the City.

It is safe to say that the system is organized to meet the many and varied demands of a large community—professional, commercial, educational, recreational and social. The Picton Reading Room (a circular building 100 feet in diameter) and adjoining rooms form the Reference Library, which contains about 200,000 volumes. In addition to acquiring the great standard works, both British and foreign, in all departments of learning, particular attention has been given to certain subjects such as architecture, the fine arts, natural history, geography, commerce and shipping. The local history section must be one of the largest in the country, and special catalogues of the books, prints and documents in this collection have been published.

The Hugh Frederick Hornby Library of fine art books and prints contains nearly 8,000 volumes of beautifully illustrated, handsomely bound, and rare editions; many thousands of modern engravings, etchings, etc.—the large majority of which are proof impressions—and a valuable collection of holograph letters and autographs. The whole Library was bequeathed to the City by Mr. Hugh Frederick Hornby, a Liverpool merchant, together with a sum of £10,000 to provide a building to

contain it. The handsome building erected forms part of the Reference Library buildings, and is entered from the Picton Reading Room in William Brown Street. It was opened in 1906. The total issue of books in the Reference Library during 1922 was 230,238 volumes.

A Commercial Reference Library was opened in 1917 in the Exchange Buildings. It contains books, periodicals, Parliamentary papers relating to trade and commerce, in addition to directories of nearly all countries in the world. The statistics of volumes consulted during 1922, viz., 175,522, partly shew that this development of Public Library work is highly appreciated by business men, but much of the work done there cannot be indicated by statistics.

Branch Libraries.—The buildings allocated to Library work in the various districts of the City have been specially designed, and are very efficiently equipped for their work. Six of these buildings were the gift of the late Dr. Andrew Carnegie, and the remainder have been erected by the City Council. Each of the larger buildings contains a General Lending Library and Reading Room, and a Lending Library and Reading Room for juveniles. The Lending Libraries for both adults and children are worked on the 'open access' system—registered borrowers being admitted to the shelves to select their books.

In addition to the ordinary stock of representative books in all sections of knowledge at each Library, there is maintained at headquarters a special stock of more advanced and expensive works for circulation through the Lending Libraries. The total stocks in the Branch Libraries for adults is 152,055 volumes. The issues from the same Libraries for 1922 totalled 1,437,849 volumes.

A special feature is made of the Library work with children, and very fine rooms are provided and suitably stocked for their use. Classes from schools attend, and, as far as possible, there is co-operation with school teachers, but the chief object is to create a good

environment, and encourage the children to develop their own tastes. The total stocks in the children's Libraries amount to 32,861 volumes, and the issues during 1922 numbered 454,545 volumes.

There are also Reading Rooms at the central building, and in various parts of the City, where newspapers and lighter literature can be perused by men and women who do not require the literature obtainable in the Reference Library. These rooms are always crowded, particularly during periods of trade depression.

Free Lectures.—The Act of Parliament under which the Liverpool Public Libraries were established gives authority to the City Council to provide Free Lectures out of the rates. The first Lectures were delivered in the year 1865, and since that date Liverpool has never been without its annual series of Free Lectures. The ensuing winter series will be the 59th. The policy of the Lectures Sub-Committee has always been to present in popular form the results of the latest developments and discoveries in literature, science and art—including travel, sport and geographical exploration. Lecturers are selected who can speak with authority on their subjects, and the names of some of the most eminent men and women will be found in the programme of these Free Lectures.

For some years prior to 1915, lectures in the outer districts of the City were regularly organised, but they were discontinued during the war, and so far it has not been possible to resume them. As many as 168 lectures were arranged for each session. During the past winter, 22 lectures were delivered to adults, and 9 lectures to children. The lectures were given in the Committee's own hall—the Picton Hall—and there was an average attendance of 1,109 at each lecture for adults. For the lectures to children, arrangements are made with the Education Committee for selected children to be sent from the schools, and there was an average attendance of 1,000 at each lecture.

LIVERPOOL AND HER PHILANTHROPY.

FREDERIC G. D'AETH,
SECRETARY, LIVERPOOL COUNCIL OF VOLUNTARY AID.

LIVERPOOL.—Population 1396—circa 1,200; 1565—700; 1700—5,000; 1750—18,000; 1792—60,000; 1831—165,000; 1901—766,000. As will be seen from these figures, Liverpool in the eighteenth century developed from an unimportant place to an important town, and in the nineteenth century from an important town into one of England's leading cities.

For her wealth, generosity and local pride, Liverpool has long been famous. Henry Smithers in his book on Liverpool, published in 1825, commences thus his chapter on Benevolent Institutions. 'To the honour of the past generations inhabiting this town and port be it recorded, that, as successful commerce affords means, the hand and heart of benevolence was ever ready to impart aid to the distressed; and it is well worthy of remark, that the magnitude of the several buildings erected for charitable purposes, and the extent of ground which they occupied, seemed rather, in the infancy of Liverpool Commerce, like prophetic anticipations of future prosperity than adapted to the then existing state of things.'

In common with other towns, Liverpool (and Walton, of which Liverpool was formerly a sub-district), possessed its share of Church doles—nine of which now remain—Berry (1601); Fazakerley (1696); Tarleton (1698); Burgess (1716); Clieveland (1730); Johnson (1775); Okill (1769), Hayes (1786); Barned (1858). Of these the Okill bequest may be taken as typical 'the interest of £40 to be distributed by the Churchwardens or Chapelwardens of the parochial Church of St. Thomas in Liverpool; in cash or bread, on St. Thomas'

Day, annually, immediately after morning service, publicly in the Chapel among such of the poor of the congregation as should reside on the south side of the old wet dock in Liverpool.'

Liverpool's first charitable institution was a small group of alms houses for sailors' widows, established in 1692, in Shaws Brow, by Silvester Richmond, and enlarged by John Scarisbrick. Other alms house bequests followed and these were amalgamated into a single scheme known as the Corporation Alms Houses (Warbrick Charity) and re-erected in 1787, in the form of a picturesque double-storied building of single tenements grouped round a rectangular courtyard. They were situate at the back of the Children's Hospital in Myrtle Street, and were only pulled down a few years ago when the charity was converted into the much more convenient form of a pension scheme. Another early pension scheme for the widows of seafaring men (and, in the early days, 'prisoners in the Borough goal') was the now wealthy Molyneux Charity (1729).

The oldest existing charity is the Blue Coat Hospital (1714), the first contributors' roll to which appeared in 1708 with the following preamble 'Whereas many poor persons are deserving of having their children taught, but are not able to afford them a Christian and useful education; and there being children whose parents are dead, and no friends left to take care of them, must unavoidably come to beggary and ruin, both in body and soul, if not prevented by the care of some charitable and well disposed people.' This charity was removed to the outskirts of the town at Wavertree some fifteen years ago, but the original building still stands in School Lane, and the recent street widening in connection with St. Peter's site in Church Street has opened out to general view this delightful piece of Liverpool's oldest lay architecture. Two other prominent orphanages are the Liverpool Orphan Asylum (1849), and the Royal Liverpool Seamen's Orphan Institution (1869).

Liverpool's first hospital was the Royal Infirmary founded in 1745, and now situate in Pembroke Place, adjoining the University. Its character is thus set out in its 1823 Annual Report. ' When to the pains of sickness are added the horrors of poverty, when the sufferer pines away in an obscurity unseen or unheard; when no kind relative is near to sooth his sorrows or supply his wants, then his heart is ready to sink within him. At such a moment the hand of benevolence throws open this hospitable mansion and dispels dispair.' In 1820, the Eye and Ear Infirmary was founded and was followed by the Northern (since David Lewis) Hospital in 1833, the Southern Hospital in 1841, and the Infirmary for Children in 1851—the first hospital devoted solely to children in England. There are at present four General Hospitals and fifteen special hospitals with a total bed accommodation of 1,890. There are also the well-known Liverpool Dispensaries (1778), several convalescent homes, the Liverpool District Nursing Association (1859) and a very active Child Welfare Association (1908).

The needs of the blind were first provided for by the School for the Blind (1791)—the first in the country, followed in 1841 by the Catholic Blind Asylum and in 1862 by the Workshops for the Outdoor Blind. The first School for the Deaf and Dumb was founded in 1826, followed in 1864 by the Liverpool Adult Deaf and Dumb Benevolent Society to deal with the more general needs of this class. The needs of cripples and incurables were first met by the Liverpool Home for Incurables (1869) followed by the Workshop and Home for Cripples (1902). With regard to Mental Welfare, apart from the Royal Albert Institution, Lancaster (1864), for the benefit of the seven Northern Counties, no actual provision was made in Liverpool until the late Miss Grayson's efforts which resulted in the founding of ' Adcote ' Laundry Home for Feeble-minded Girls in 1892. Other special Homes followed, but it was only in 1915 that the general needs of this particular class were met by the formation of the West

Lancashire Association for Mental Welfare. In 1888, the Home for Epileptics was founded at Maghull on the outskirts of the city.

Immorality is to be found in Liverpool as in other large towns. The Liverpool Female Penitentiary was founded in 1810. The Liverpool Benevolent Institution in 1838, the Liverpool Magdalen Institution in 1855, the Convent of the Good Shepherd, Ford, in 1859, The Home in 1861, and the Liverpool Midnight Mission (since closed down) in 1875. With regard to delinquency and crime the Liverpool Certified Industrial Schools (closed down 1922) were founded in 1849, the Liverpool Juvenile Reformatory Association in 1854, and the Catholic Reformatory Association in 1864. In 1823, the Liverpool and Lancashire Female Refuge was founded as an alternative to prison in certain cases, the Liverpool and South-West Lancashire Discharged Prisoners' Aid Society was founded in 1866, and work in the Police Courts was commenced in 1879 by the Police Court Mission (C.E.T.S.).

Numerous societies and institutions exist for the relief of poverty. Among the more prominent efforts may be mentioned, in addition to the orphanages mentioned previously, the Liverpool Central Relief Society (1863), based on the Society for bettering the condition of the Poor (1808), and the Liverpool Charitable Society (1823), the Society of St. Vincent de Paul (1847), the Jewish Board of Guardians (1875), the Liverpool Merchants' Guild (1868), the Sheltering Homes for Destitute Children (1872), a valuable emigration agency, and the Training Ship 'Indefatigable' (1865). Cases of hardship and difficulty are now so varied that in 1918 the Liverpool Personal Service Society was formed and has already become one of the most active organisations in the City.

The needs and requirements of the ordinary citizen have not been overlooked. The Gordon Working Lads' Institute was formed in 1885, the Bankhall Girls' Institute in 1887, and the Florence Institute for Boys in 1888. Liverpool is now covered with a network

of Clubs, Scout Troops, Girl Guides, Companies of the Boys' Brigades, etc. In 1890, the Liverpool Union of Girls' Clubs was formed, in 1911 the Liverpool Union of Boys' Clubs, and the whole of the juvenile organisations of the City united to form, in 1917, the Liverpool Juvenile Organisations Committee to further their general welfare. The movement for social recreation among adults came somewhat later, and there are now in the City a number of Clubs for men and women, most prominent among which are the David Lewis Club (1906); and the two Citizens' Institutes formed in connection with the Liverpool Citizens' Institutes Association (1918). In connection with the general well-being of the town should be mentioned the Victoria Women's Settlement, founded 1897, and the University Settlement for Men, founded 1907.

This survey of local philanthropy may conclude with Liverpool's attempt to co-ordinate this valuable and extensive voluntary effort into a related whole. As far back as 1819, the Charitable Institution House was founded for *inter alia* '. . . . the purpose of collecting reports and records of charitable institutions.' In the nineties the late Mr. William Grisewood, Secretary of the Liverpool Central Relief Society, brought into being an 'Association of Charities' which met periodically for several years. He was, however, conscious of the need for some more permanent body, and in April, 1909, the then Lord Mayor of Liverpool (Mr., now Judge, H. C. Dowdall) acting on one of the recommendations of the recently issued Report of the Poor Law Commission, convened an important Conference of Liverpool Charities in the Town Hall, which resulted, in the following year, in the establishment of the Liverpool Council of Voluntary Aid. This important body representative of both voluntary agencies and local public bodies under the able guidance of Chancellor H. C. Dowdall, its first Chairman, and latterly his successor, Mr. Charles Booth, is an active and responsible force in the city (a) in promoting the efficiency of voluntary organisations; (b) in furthering

co-operation between them and the public bodies; (c) in initiating new voluntary effort where required; (d) in maintaining a mutual register of assistance; (e) in the issue of an Annual Social Workers' Handbook and a quarterly periodical. The Council also administers the Liverpool Council of Voluntary Aid Charities' Fund, founded in 1918 by an anonymous donation of £50,000 and since increased by donations and subscriptions. This Fund which is unique in character (a) makes annual grants to the general body of Liverpool charities in proportion to their subscription lists; and (b) makes special grants towards various forms of capital expenditure, etc. Finally, in dealing with this general question of co-operation of voluntary effort must be mentioned the joint collection of subscriptions and donations organised by the Central Relief Society in 1877, which now collects and distributes to charities some £30,000 annually.

The social needs of the people vary from generation to generation, and as social conditions steadily improve and new problems arise, needs once urgent pass—such, for instance, as the Liverpool Dorcas and Spinning Society (1817); the Society for the Encouragement of Servants (1820); Training Home for Girls (1874); The Newsboys' Home (1870); Nash Grove Ragged School (1866). At the present time, however, there are some 130 Liverpool charities with a total annual income from legacies, donations and subscriptions for the year 1921 of over £150,000. This, too, is quite apart from numerous educational and religious institutions which are not included in the above survey.

PUBLIC HEALTH ADMINISTRATION IN LIVERPOOL.

E. W. Hope, M.D.,
Medical Officer of Health.

In order that the present system of public health administration in Liverpool may be readily understood, a brief reference to earlier developments is necessary.

Earlier Conditions and Development.

The unenviable notoriety for disease and mortality which, in varying degrees, characterised Liverpool right up to the late '80's, was due in a large measure to the extremely rapid growth of the city, which took place at a period when public health requirements were little known, and less regarded, and when no adequate legal powers existed to enforce even elementary requirements; the geographical situation of the port, and the growing trade with all parts of the globe, rendered the district peculiarly vulnerable to imported disease, which found every condition favourable for epidemic spread. The First Report of H.M. Commissioners upon the Health of Large Towns (1844) throws interesting light on these conditions.

Health and Commerce.

The close connection between commercial prosperity and public health progress, was early recognised; for example, the need of a water supply for the city received emphasis not so much from the mass of suffering and disease resulting from the deficiency, as from the financial loss involved from destructive fires which there was no water to extinguish. Since those days the principle of associating health advance with commercial progress has been adopted with good effect.

Pioneer Legislation.

The Liverpool Corporation and the leading citizens, impressed by the magnitude and frequency of epidemic visitations, as well as by the absence of legislative powers to deal with them, on many occasions obtained from Parliament powers to deal with the great sanitary defects, and it is interesting to note that as the value of the pioneer sanitary legislation became proved and known, many of the provisions were adopted by other municipalities, and were ultimately incorporated in general Acts of Parliament applicable to the whole country. The long list of Sanitary Acts of Parliament initiated by Liverpool's necessities includes measures designed to secure protection from infection, to improve and cheapen removal of unhealthy areas, to promote schemes for Housing and Town Planning, to ensure purity of food, to minimise tuberculosis, to promote the welfare of motherhood and infancy, and many other measures, wide, comprehensive, and of the highest importance from the health point of view; bearing in mind her very large necessities, there is small wonder that Liverpool has always been in the fore-front of experimental and pioneer health work—fortunately, in the main, successful.

Conditions in 1896 and Subsequent Progress.

The British Association last met in Liverpool in 1896, just 27 years ago; in the preceding year (1895), the incorporation of the hitherto separate townships of Walton, West Derby, Wavertree, and Toxteth, with Liverpool, had taken place raising the population of the enlarged City of Liverpool to 641,063. Sanitation had already made very great progress, but the death-rate of the entire City of Greater Liverpool still stood at 22 per 1,000 of the population. Since that year, strenuous efforts, attended with considerable outlay, have been made to improve the Public Health and this rate has progressively diminished until in 1922, with a population increased to 823,095, it had fallen to 14.6

per 1,000, representing a reduction in the annual rate of loss of life, of one-third.

In 1896, out of every thousand infants born, 175 failed to attain the age of 12 months, the comparative figure for 1922 was 96 per 1,000 births, shewing that the annual destruction of infant life has, in the meantime, gradually diminished to about one-half. Since 1896, the arrest in the prevalence and fatality of communicable infections has been no less remarkable; in that year there were 2,311 deaths from zymotic diseases. In 1922 with a population increased by one-third, 1,312 deaths were registered as being due to these causes, representing a loss of life of one-half relative to the increased population. Some of these infections, formerly so destructive have wholly vanished from the City, probably never to reappear, excepting as sporadic or imported cases.

Public Health and Individual Hygiene.

It is now fully recognised that a modern and effective system of Public Health Administration must go far beyond those aspects of the case which until recent years were the main concern of Sanitary Authorities —such, for example, as are dealt with under the Housing and Town Planning Acts, the supply of water, control of food supplies, provision of Hospitals, Parks, Recreation Grounds, Baths and Wash-houses, cleansing of streets, construction of sewers and other fundamental needs—added to all of these comes the necessity for close personal association with the population, notably that section which stands most in need of guidance. This has been met by the Liverpool Sanitary Authority (Health Committee) by the employment of a large staff of carefully selected and specially trained women in the capacity of Health Visitors, special Home Nurses for Measles, Whooping Cough and Ophthalmia Neonatorum, School Nurses, and in kindred ways, who render most valuable service, and who supplement and link up with many professional, charitable, and voluntary associations, such as the Queen Victoria District

Nursing Association, the Midwives' Association, the Child Welfare Association, and many others.

Great pains have been taken to encourage the midwives (who attend 75 per cent. of the births in the city) to form themselves into an Association, and to work in close co-operation with the Public Health Department. Long before the practice received Parliamentary and Ministerial sanction, the Liverpool Health Committee had in operation a complete scheme which ensured that any midwife meeting with an emergency in her practice could, without delay, secure the services of a medical practitioner, the fee being paid by the Health Committee in all necessitous cases.

The comprehensive, and still developing scheme for the welfare of maternity, infancy and childhood, embraces numerous Centres and Clinics at which expectant mothers, or mothers with their infants may attend, a valuable addition to this work being the Model Welfare Centre, the gift of the Carnegie United Kingdom Trust, now approaching completion on a site (Cambridge Street) in close proximity to the Royal Liverpool Children's Hospital, and the proposed new Maternity Hospital.

The declaration of war by Germany in 1914 necessitated the total suspension of rehousing operations, but the work has now been resumed with great activity. These operations are the subject of another article (see page 60).

Medical Inspection of School Children.

In the year 1907, as the result of the efforts of Mr. Russell Rea, Parliament sanctioned a valuable legislative measure, designed to secure the medical examination of every child attending a public elementary school, at least three times in the course of its school career, the object being the detection and early treatment of any incipient condition likely to prejudice the health and future prospects of the child. This has proved directly and indirectly one of the most valuable

auxiliaries in Public Health Administration, and has the warm support of the Ministry of Health and Board of Education.

Tuberculosis.

The Scheme for the prevention and treatment of tuberculosis embraces important sanatoria at Fazakerley, Highfield, Parkhill, and Delamere, three tuberculosis dispensaries, and, also, complete arrangements for the domiciliary treatment of those who, for various reasons, it may not be expedient, or necessary, to admit to a sanatorium. The treatment of surgical tuberculosis in children is undertaken at the Leasowe Children's Hospital, where excellent facilities exist for this work. Voluntary hospitals for children, such as the Royal Liverpool Children's Hospital, in Myrtle Street, and the Royal Liverpool Country Hospital for Children at Heswall—now amalgamated—do not come within the scope of this article. Surgical treatment of adults is dealt with at the Fazakerley Sanatorium, 90 beds being available for that purpose. At the Fazakerley Sanatorium, and Parkhill Sanatorium, children of school age benefit from systematic tuition under a certified teacher, the mental stimulus having proved to be a decided factor in the recovery of many of the children under treatment. The therapeutic value of regular exercise and suitable employment, in the case of adults is fully recognised, and gradually increasing facilities have been provided for both males and females at the Fazakerley and Parkhill sanatoria.

The system of Isolation Hospitals is modern, up-to-date, and complete; six institutions suitably situated for the needs of the population and containing between them some 1,200 beds are provided, and their value to the City has been incalculable.

Close attention is given to the question of the prevention and treatment of Venereal Diseases. Clinics have been established where free treatment and advice by specialists are available in connection with four of the large general hospitals in the city. The attendances

at these clinics are large, but as a considerable number of patients give up attendance before they are free from infection, the City Council feel that if the scheme, and the expenditure which it involves, is to be fully justified, powers are necessary to ensure a more systematic attendance.

Full Details in Annual Reports.

Full reference to all the valuable undertakings briefly referred to in this short article, will be found in the Public Health Reports issued annually by the Medical Officer of Health.

Public Health and Education.

A third aspect of Public Health Administration—no less important than the two already referred to—consists in education on the subject. One of the difficulties which confronted Sanitary Authorities, was, in finding suitably trained and educated candidates for appointment in the various sections of the staff and this could be met in one way only, by the establishment of an efficient teaching centre.

School of Hygiene.

Happily, the University was in a position to give considerable assistance in this matter and following upon liberal gifts by Lord Leverhulme, Mrs. and Miss Holt, and others, an agreement was reached between the City Council and the University which resulted in the establishment of the University School of Hygiene, in Mount Pleasant. Here, facilities are afforded for the teaching and training in all branches of sanitary administration; candidates for the Diploma in Public Health, health visitors, medical students, school nurses, midwives, sanitary inspectors, food inspectors, students of social science, school teachers, and so forth, attend the courses.

Connected with the School is a Museum of Hygiene, which is always open to the Public. The members of the British Association are invited to visit this School

and Museum, where are also located the City Laboratories (Bacteriological and Chemical) in which the analytical work of the city is carried out under the supervision of the City Bacteriologist and the City Analyst, and the teaching in these subjects is given.

Port Sanitation.

A brief reference is necessary to the highly important section of Port Sanitation. It is in the Port that the close relationship between public health and commercial prosperity, and the international aspects of health problems, receive their strongest emphasis. Any slackness or neglect in regard to health supervision in the port would in all probability lead to the introduction of foreign infections, such as plague and cholera, and subsequently to difficulties being placed in the way of vessels from this port on their arrival in foreign ports. The closest possible attention is paid to every detail of sanitation, including the fumigation of vessels, and to the medical examination of passengers and crews arriving from or en route to foreign ports. As part of the scheme for the prevention of Plague, a special staff is regularly employed in the campaign for the detection and destruction of rats on board ship and in the docks and warehouses, a large percentage of the rats caught being submitted to the City Bacteriologist for examination with a view to the detection of plague, or other infection.

Hydrocyanic Acid Gas disinfection has been resorted to, with excellent results.

The Consular Corps.

The Consular body are strongly represented in Liverpool, more nationalities being represented than in any other city in the world, and they are kept fully informed, by means of weekly reports, of the health position in the Liverpool Port Sanitary Area, and duly communicate that information to their respective Governments. Any special incident in

regard to imported infection or other vital subject is immediately communicated to them. Cordial relationship exists between the Port Sanitary Department and the Consuls, and as a consequence the work in its international aspects is carried on harmoniously.

Co-operation with H.M. Customs, M.D. & H.B., and Shipping Companies.

In the sanitary administration of the port an important part is played by the officers of H.M. Customs, who, being usually the first to board any vessel, make certain enquiries concerning the health of those on board during the voyage, and without such valuable assistance it would be necessary for the Port Sanitary Authority to maintain a very costly staff. The co-operation of the Mersey Docks and Harbour Board is no less important; by arrangement, no vessel coming from a plague-infected port can enter a dock unless the master of the vessel possesses a certificate of clearance from the boarding medical officer of the Port Sanitary Authority.

It remains to be added that shipowners and their staffs are no less willing to give every assistance in their power to observe and carry out regulations designed with a view to maintain the health status of the Port.

THE TRADE AND COMMERCE OF LIVERPOOL.

J. Sandeman Allen,
Chairman of the Liverpool Chamber of Commerce.

When the British Association visited Liverpool in 1896 Sir William B. Forwood—who is now father of the City Council, and was then President of the Chamber of Commerce—wrote a paper on the Trade and Commerce of Liverpool for the Handbook of that visit, but such is the change wrought by the development of trade in the last 27 years, that except for the historical and geographical descriptions, the information contained in that interesting paper must be classed among the records of the past.

In dealing with the subject to-day one would take it up from a different point of view, and show why Liverpool is different from any other city or town in the country—and indeed in the Empire.

In places like York, Chester, Norwich, Exeter, etc., we have cathedral cities, and in Oxford and Cambridge seats of learning, which, though they have developed factories and trades of some kind, stand pre-eminent as sign-posts of the old days round which, like the ivy on their cathedral and church towers, clings the wonderful history of our country with all its fine traditions.

Then we have the great industrial centres, such as Manchester, Birmingham, Sheffield, as well as the Cotton-spinning towns of Lancashire, and the woollen manufacturing districts of Yorkshire. Some of these places have considerable antiquity, but to-day their great industries are dominant. Therefore, while they may be local centres of learning, and full of various social activities, each one is characterised by its special industry or industries.

Liverpool, on the other hand, is not primarily an industrial centre, and although it dates back to 1173, and has been linked up with the history of expeditions to Ireland and elsewhere, the part it played in the history of England—until the middle of the 18th century—was uneventful. Of course, its citizens very naturally cherish with pride the few ancient landmarks which still remain to remind them that 'Lyrpul' had its part in those old days in which, notwithstanding the glamour of romance through which we see them, life, with its strivings, its passions, and its ambitions, was pretty much the same as it is to-day.

The only city that can be compared suitably with Liverpool is Bristol, its ancient rival. Bristol was flourishing when Liverpool was a village, but it was the development of commerce and trade in the time of Queen Elizabeth which brought it into prominence. As, however, ships grew in size, and manufactures developed, the geographical position of Liverpool decided once for all her supremacy as the principal seaport of the country. Although Liverpool to-day is a great centre of education, with an excellent educational system and a modern university, her importance as a city, and indeed, the very existence of her trade and commerce, depend upon her position as the gateway of the country for its overseas trade.

It is this fact which stamps Liverpool with her individuality, and distinguishes the structure of her physical, social, and commercial being from those of other cities and towns in the country—or, indeed, in the world.

When the transformation of England from an agricultural country to the greatest industrial country in the world took place, Liverpool, from being a comparatively small, though important, port, gradually became the largest seaport in the world —for into her docks came the produce and commodities imported from every quarter of the globe; while her ships carried over the seven seas the manufactured

articles required in every country of the world. As a writer says:—

'Its peculiar suitability for the leading position 'in foreign trade needs no special demonstration. 'The features of the Port itself and its surroundings 'are evident from even a cursory examination of the 'map, which shows a capacious roadstead on the 'westerly side of Great Britain, approached by wide 'and deep sea channels, and affording safe anchorage 'for the largest vessels, of easy access north or south 'of Ireland from the great oceans; and this on the 'shore of Lancashire, with which the adjoining 'counties having, like itself, abundant stores of coal 'and other minerals, has been marked out by nature 'as the most suitable centre for the great industries 'finding their home in Great Britain, and especially 'in this hinterland of Liverpool, since the invention 'and development of the steam engine and the power 'loom.'

It must not be supposed, great as her natural advantages were, that it was an easy matter to transform Liverpool into what she is to-day. The rise and fall in the tides of the Mersey, with the considerable changes in depth, made it impossible to run ocean-going vessels alongside open quays as is done in New York and similar harbours. Moreover, apart from that, as the roadstead is exposed to the north and north-westerly gales, it would, in any case, be unsafe to do so. Fortunately for this country, and for Liverpool, these physical difficulties have been overcome, and we have to-day, on both sides of the river, a vast system of docks of various sizes, providing safety for vessels, and ample quay space for the cargoes they have to load or discharge.

As the subject of the docks is being dealt with in a separate paper by one better qualified to do so, no more need be said on the matter here, the present object being to show the commercial development of the city, and how everything centres round its overseas trade.

Liverpool has grown round the port just as old Liverpool spread round the old pool and harbour, where ships used to lie on the mud when the tide went out. As the docks grew, the semi-circle extended, but always had the river as a base, so that to-day, with six miles of docks, we have the town spread out as a semi-circle or fan. The nerve centre remains in the small area which formed the port, and is less than a mile long, and not more than half-a-mile in depth.

From the Dock Offices, the Cunard and Liver Buildings, the fan spreads out by Chapel Street, Water Street, and James Street, to the Cotton Exchange on one side, and the Customs House on the other, with Castle Street, and North and South John Streets bisecting it, until we reach the Old Haymarket. In this small area is concentrated the commercial and municipal control of the Port and of the City, and through most of these streets are constantly passing carts laden with cargoes which the ships have brought from, or are carrying to, every part of the world. The Liverpool citizen, therefore, from youth upwards, is familiar with the shipping of the world, either at anchor in the Mersey, alongside the Landing Stage, or in the Docks, loading and unloading passengers and cargo for and from every country. He also sees daily the actual contents of the ships, *e.g.*, bales of cotton from U.S.A., Brazil, Egypt and India; wool and meat from Australia, New Zealand, Patagonia and the Argentine; tobacco, hams, bacon, lard, canned meats, fruits, vegetables, etc., from U.S.A., British Columbia, Australia, and elsewhere; hemp, raw sugar from the Indies, West and East; timber from Canada; as well as crates and packages of machinery, cast-iron, cotton and woollen goods, and every kind of manufactured article.

This, of necessity, produces a familiarity with, or at least a knowledge of, the nature, products, and trades of many countries of the world, and develops that cosmopolitan atmosphere and interest which, to a certain extent, distinguishes the Liverpool citizen from

the inhabitants of other commercial towns, who by their environment, are necessarily concentrated upon their own products.

Shipping and all connected with it being the paramount feature of the Port, and overseas trade being consequently the main object of most of its inhabitants, we find the educational system bending in that direction. The Technical and Commercial Schools concentrate on those subjects which are most likely to qualify the youth of the City for its future life, and even in the University we find the departments of chemistry, engineering, commerce, marine law, and kindred subjects specially prominent. The Medical School, too, has an excellent reputation, while the Tropical School of Medicine has a world-wide reputation. It should also be noted here that the City Council, with the assistance of the Chamber of Commerce, has provided an excellent Commercial Reference Library in the centre of the business quarter. It contains all books and official publications bearing on commerce and trade, and is largely used by our business men.

The shifting population, the long absences from their homes of the seafaring men, and the great amount of casual labour, all create special social and educational problems. Day industrial schools are maintained to provide for the children of these classes in a fuller way than the ordinary elementary schools can do. Glasgow, from the same cause, is the only other city where this social need exists.

Then again, the large shops and the retail houses, large and small, have to consider the demand of shipping and seafaring men visiting foreign countries —tropical and otherwise—to an extent not found elsewhere outside the Metropolis.

Even the charities of the town, and the hospitals, have also that cosmopolitan stamp which is so characteristic of the City and Port.

Interesting as all this is, we shall see that in this very diversity of interests lies the weakness as well as the strength of Liverpool.

Other cities have been built up around special industries and trades, consequently, while their interests may not be so varied, they are homogeneous, and as a result the leaders in industry and commerce take a direct interest in the government of their cities, as well as of their industries, so that all strength is combined in the furtherance of one common purpose. In Liverpool, on the other hand, the Port is controlled by a separate body—the Mersey Docks and Harbour Authority—who are supreme as to Port regulations, dues on shipping and cargoes, and the handling of goods on the Dock Estate. This unique body is managed by a Board composed almost entirely of leading commercial men elected by all persons paying dues. The mode of election is no doubt antiquated, and practically results in leaving the nominations in the hands of the shipping and other old associations, but in spite of some anachronisms, the Board has done, and continues to do, splendid work in the development of the Port. Otherwise the commercial interests are so diverse, and the trade and commerce so general in scope, that the commercial community is in danger of concentrating upon its own sectional interests rather than on the interests of the City and trade as a whole.

For these two reasons the Municipal Government is, to a large extent, separate from the large shipping and overseas commercial interests, and is mainly in the hands of the energetic men who control the large retail trades, and other necessary works and occupations to be found in all great cities.

Unfortunately, few of the leading shipowners and merchants have entered the municipal arena, but in recent years, owing to the enormous increase in rates, leaders of trade and commerce are realising how seriously such charges hamper trade, and, consequently, they are taking a greater interest in all local affairs.

In its Mayors and Lord Mayors—the change in title took place on the 3rd of August, 1893, when the Mayor, the late Mr. R. D. Holt, was created Lord Mayor—Liverpool has usually been fortunate in securing one

of its prominent citizens, and thus the dignity of that office has been well maintained.

In the foregoing remarks an endeavour has been made briefly to show how the peculiar character of its trade has placed a stamp on the physical, social, and commercial life of the City. Reference has already been made to the nerve centre of the City, and in this connection one would say here that in former days the open square behind the Town Hall, known as the Exchange Flags, was used for general exchange, including cotton and other commodities, while in the News Room adjoining, merchants, ship brokers, and others congregated daily, and a large amount of the trade of the Port was carried on there. In more recent times, however, the Corn Exchange, Provision Exchange, and the Cotton Exchange were established, and practically all the business of these trades are conducted in their own Exchanges—as has always been the case with the Stock Exchange. The Exchange Flags, therefore, are now deserted, and the News Room is mainly used by General Produce Brokers and Merchants, and Shipping and Forwarding Agents, as well as for the supply of news. The shipping news is supplied by the Liverpool Underwriters' Association, and their room, close to the News Room, is available for Underwriters, Merchants and Shippers who rely more particularly upon shipping information.

The interests of the leading trades in Liverpool are controlled by separate Associations, some of them more than a hundred years old.

The Liverpool Underwriters' Association, established in 1803, is the oldest to-day, and was founded by Underwriters, Shipowners and Merchants in the days when private underwriting was a very large business here. It is now controlled by the Marine Insurance Companies, whose trade is second only in volume to London.

The Shipowners' Association was established in the days when sailing ships carried most of the trade in

and out of Liverpool. It still exists, but naturally, with the decay of sailing ships, its sphere of operation is greatly restricted.

The Liverpool Steamship Owners' Association is one of the most powerful in the country, and, so far as shipping is concerned, in the world. It controls about two-fifths of British shipping, and comprises the majority of the liners as distinct from the tramp steamers.

The Liverpool Cotton Association is a very important body controlling, as it does, the cotton trade of the country (not only the cotton exported from the U.S.A., but also from Brazil, India and Africa) which forms the most important in point of value of the raw products imported to Liverpool.

The Liverpool Corn Traders' Association also controls the large import trade of wheat and maize, and in addition includes the important milling interests in the district.

Among the many Associations existing in Liverpool, too numerous to mention, are:—The United General Produce Association, Liverpool Provision Trade Association, Ltd., The Liverpool Timber Trade Association, and various Fruit Associations.

These Associations direct their attention exclusively to matters concerning and affecting the trades of their members. They are, however, affiliated with the Chamber of Commerce which watches over the general interests of the trade and commerce of the Port, and they have representatives on the Council of the Chamber.

Some of the large trades, particularly the West African, the Canned Goods trade, and the South American trade, as well as all the important but smaller trades, prefer—no doubt wisely—to protect the interests of the trades as separate sections of the Chamber of Commerce. The Chairman and Deputy-Chairman of each section, however, are members of the Council of the Chamber.

The Chamber of Commerce, established in 1850, has a membership of some 1,400, consisting of firms and individuals, manufacturers, merchants, shipowners, lawyers, accountants, and bankers. The Rt. Hon. The Earl of Derby, K.G., has been President of the Chamber since 1908. The Council consists of 24 elected members from the general body, as well as representatives of the Mersey Docks and Harbour Board, the Trade Associations, and the Trade Sections above referred to.

The work of the Chamber not only covers questions of purely local interest, but all questions dealing with overseas trade in the whole field of this country's trade and commerce. Locally, it endeavours to help its members in connection with matters affecting railway and road traffic, shipping and handling of goods, warehouse facilities, Customs and Excise, postal and telephone facilities, and similar local questions. At the same time it deals directly with H.M. Government on questions of taxation and legislation affecting shipping and commerce, as well as through its affiliation with the Association of British Chambers of Commerce and the International Chamber of Commerce since its establishment a few years ago. The Chamber has representatives on the Executive Committees of both these Associations, and makes its power felt in all general questions affecting trade. In recent times the importance of such an organisation has been more appreciated, as merchants and others have realised that these general issues have as much, if not more, effect upon their individual trades than even the particular questions arising in their trades, with which they, themselves, are best qualified to deal.

From these remarks it will be realised that the organisation of the vast and varied trades of the Port is adequate for all requirements—although in this, as in everything else, much depends upon the personal element.

The following few statistics illustrate the importance of the trade in Liverpool:—

The value of the total imports and exports of Liverpool for the year 1922 amounted to £528,000,000, as compared with London £607,000,000, and the next port, Glasgow, £95,000,000.

Comparative figures of quantities are not obtainable, but it should be borne in mind that goods imported to London are of much higher value in relation to quantity than the large bulk cargoes imported to Liverpool.

The tonnage of ships entering and leaving Liverpool in 1922 amounted to 31,645,368; London, 25,730,336; and Glasgow, 11,807,274.

Thus it will be seen that in spite of keen competition from other ports, Liverpool is maintaining her position as the premier port.

Unfortunately, since the war, returns of quantities and values, of imports and exports, are not given in the detailed way in which they used to be furnished, so that it is not possible to supply an analysis or a comparative table of the various classes of raw produce and of manufactured goods passing in and out of Liverpool, but the following notes may be of interest in connection with the principal imports:—

Cotton.—Total number of bales imported into Liverpool for the year ended 31st December, 1922:—

1,703,831	bales	American Cotton.
120,483	,,	Brazilian ,,
283,340	,,	Egyptian ,,
243,299	,,	Peruvian ,,
15,356	,,	West Indian ,,
60,953	,,	African ,,
93,447	,,	East Indian ,,

Total—2,520,709 bales.

Sugar.—Raw and partly refined Sugar imported into Liverpool from January 1st to December 31st, 1922:—

438,571 tons—*approximate value*, £8,771,430.

Wholly refined Sugar imported into Liverpool from January 1st to December 1st, 1922:—

30,566 tons—*approximate value*, £733,584.

Fruit.—Total amount of *Dry* Fruit imported into Liverpool for the year ended 1st July, 1922:—

110,566 tons.

Total amount of *Green* Fruit imported into Liverpool for the year ended 1st July, 1922:—

250,978 tons.

There are no values on record for this period, but it is a matter of interest that the returns for the year ending 31st December, 1921, are as follows:—

Dry.			Green.	
Tons.	Value.		Tons.	Value.
82,653	£5,891,104	...	360,919	£8,775,826
		Tomatoes	23,439	£863,805

Tobacco.—The total amount of unmanufactured Tobacco imported in Liverpool during the year ended 31st December, 1922:—

68,160,293 lbs.—*value*, £6,205,531.

Corn Trade.—(Figures kindly supplied by George Broomhall's *Corn Trade News*.) Total imports to Liverpool for year ending 31st December, 1922:—

Wheat ...	4,562,300 quarters	...	value, say	£11,919,009
Flour ...	369,000 ,,	...	,, ,,	£913,275
Maize ...	1,961,200 ,,	...	,, ,,	£3,432,100
Oats	200,200 ,,	...	,, ,,	£320,320
Barley ...	140,500 ,,	...	,, ,,	£252,900

Timber Trade.—The figures for 1921 were not normal, in 1920 the importations of timber into Liverpool were:—

Sawn Softwoods	281,931,600 feet
Hewn Hardwoods	33,415,644 ,,
Sawn Hardwoods	53,163,096 ,,
Staves	13,481,400 ,,
Total of ...	318,001,740 ,,

This represented a value of £10,235,274, also approximately 50,000 tons of Mahogany and 32,000 tons partly manufactured goods valued at about £1,500,000.

Meat Trade. —Imports into Liverpool for year ending 31st December, 1922:—

Chilled Beef		
Frozen Beef...		
,, Mutton & Lamb		
,, Pork	198,500 tons.	
,, Rabbits	approx. value, £8,250,000.	
,, Tongues ...		
,, Offal, &c. ...		

An endeavour has been made to give a brief résumé of the character and development of Liverpool in connection with its trade and commerce overseas, because its special importance lies in the fact that it is a leading port and a distributing centre for feeding and clothing a large industrial district containing some ten million people. No account, however, would be complete without a reference to some of the leading industries in the districts which all contribute to the importance of Liverpool as a commercial centre, but which are frequently overlooked when Liverpool is spoken of.

Liverpool and district is the largest milling centre in the country.

At Birkenhead we have Cammell, Laird's important shipbuilding yards, as well as large ship-repairing yards on both sides of the Mersey.

At Port Sunlight are established the largest Soap Works in the world.

At, and near, Widnes we find the United Alkali Company, and almost all the leading chemical factories of the country.

St. Helens is the home of the plate glass and other glass industries.

From the foregoing remarks it will be realised how, by the ramifications of its trade and commerce, this

Port is connected with practically all the industries, and the international commerce, of the British Empire.

The City has developed in importance as the commerce and industries of the Empire have developed, and it follows that its future prosperity must depend upon the extent in which the facilities of the ports for such commerce and industries are maintained and extended on progressive and economic lines.

THE MERSEY DOCKS.

L. A. P. Warner, C.B.E.,
General Manager and Secretary of the Mersey Docks and Harbour Board.

In the Merseyside towns — Liverpool, Bootle, Birkenhead and Wallasey—there is a district second in the British Isles only to the Metropolis as regards population. Yet only a little over two hundred years ago this same district consisted of a few scattered farms and a little fishing village, doing perhaps a small coastwise trade with other local coastal villages, and the stranger naturally enquires what has occurred during these two centuries to cause this rapid concentration of population. The answer is that the development of this district is primarily due to the advent of the Mersey Docks.

From the panoramic view of the Port of Liverpool, included in this Handbook, it will be noticed that the Docks are almost encircled by the towns mentioned, but to obtain a really comprehensive idea of the district one must imagine to the left of the view the Irish Sea, while to the right, it must be understood, lie the upper reaches of the River Mersey. It is in these upper reaches that the river attains its maximum breadth of some three miles, but at its estuary, where the Port is situated, the river has only an average breadth of about three-quarters of a mile. The tidal range on the Lancashire and Cheshire coast reaches 30 feet (in certain seasons even more), and the result is that there is a large volume of water constantly flowing into or out of the wide upper reaches through the narrow neck, naturally scouring the bed of the river there to such an extent that exceptionally deep water is available at even the lowest tide. The

current, however, as might be expected, is both swift and strong, and in the early days of Liverpool's history the small sailing vessels of those times were thereby prevented from anchoring in safety before the town, with the result that their owners refused to trade to Liverpool, and only the smaller craft, which could stand being beached on the foreshore to unload between the tides, were the users of the otherwise magnificent and naturally sheltered harbour. Necessity, however, again proved to be the mother of invention, and the current, primarily Liverpool's curse, has proved to be the Port's blessing. At the commencement of the seventeenth century the necessity was for a port on the doorstep of Lancashire, Yorkshire and the Midlands, those English industrial districts which, then commencing to come into prominence, have since raised England to a position of pre-eminence among the manufacturing countries of the world. Its geographical position and the shelter and deep water in the harbour fitted Liverpool for the work, but the rapid and (to the small vessels of those days) dangerous current had laid its curse upon the river. Necessity, however, knows no law, and the necessity for a port in this district brought to Liverpool, shortly before the close of the seventeenth century, the inventor, in the person of Thomas Steers. This inventor solved the problem which had so long confronted Liverpool by designing a dock in the old 'pool,' with flood-gates leading to the river, so that vessels might enter the dock at high water and, by the closing of the gates, be kept afloat in safety out of the dangerous current while discharging or loading their cargoes. Mr. Steer's famous report is dated 1708, and resulted in the constitution of the 'Old Dock,' Liverpool, which revolutionised dock construction throughout all parts of the world where there is any tidal range. The result was that the menace of the rapid current of the Mersey to the small barque—the modern steamship treats it with contempt—having been overcome, the Port of Liverpool progressed from success to success

Bird's eye view of the Port of Liverpool.

ıtil the Mersey Docks have now become the most tensive in the world, and the Port deals with a third the overseas trade of the United Kingdom, distribut-.g many of its imports not merely to those industrial stricts to which I have previously referred and to hose well-being it has become such a necessity, but so to the most remote parts of the kingdom. It will ow be understood why it is claimed that Liverpool, ootle, Birkenhead and Wallasey owe their importance, not their existence, to the advent and progress of the ersey Docks.

The Liverpool 'Old Dock,' the pioneer of all modern ocks, although of such historical importance, was a ry humble affair compared with any of the gigantic ocks of modern times. Its retaining walls were rincipally of brick, with stone copings, and its water rea was only 3 acres, 1,890 square yards, the entrance nd the tidal basin into which it entered containing acre, 2,897 square yards, while there was also on the orth side of the basin a small graving dock. But her docks, the Salthouse, George's, King's, Queen's, nion and Prince's, followed. In 1824 the Dock Trust ppointed as their Engineer Jesse Hartley, who proved ne of the most enterprising and successful dock nstructors this Port has had. Mr. Hartley built his ocks in granite, and altered the policy of his redecessors by designing the docks in the shape of ght-angled parallelograms, each with its narrowest nd facing the river so as to utilise the river front to s greatest extent. Under his direction the Canning, larence, Brunswick, Waterloo, Victoria, Trafalgar, oburg, Toxteth, Albert (the first dock with ware-uses on the quays), Salisbury, Collingwood, tanley, Nelson, Bramley-Moore, Wellington, Sandon, uskisson, and Wapping Docks were completed, the st being opened in 1855.

In 1843 a Company, called the Birkenhead Dock ompany, had been floated and had introduced Bill into Parliament for the conversion of the allasey Pool, on the west bank of the Mersey,

into docks, the Morpeth and Egerton Docks, designed by a Mr. C. E. Rendel, being opened by them in 1847. The Company, however, did not prove a financial success, and sold their estate to the Liverpool Corporation in 1855.

During the years immediately preceding 1857 there had been much friction between the Liverpool and Birkenhead dock authorities and the general body of traders, and this resulted in the latter year in the creation of the Mersey Docks and Harbour Board by Act of Parliament, the new Board being constituted the sole authority for the Port, including the Docks on both sides of the river.

The Mersey Docks and Harbour Board is a Public Trust composed of 28 members, of whom 24 are elected by the Dock Ratepayers and 4 appointed by the Government. This Trust is governed by Acts of Parliament, and must be run for the benefit of the community and not for profit. Its capital expenditure is met by money borrowed from the public at rates of interest which are fixed for the term of the loan. Any surplus revenue must be devoted to maintaining and bettering the Estate, reducing rates and dues on ships and goods, or reducing the capital debt. An elected member of the Board must live within the Borough or Customs Port of Liverpool, or within ten miles of the boundary of the Port, and must pay to the Board within the year preceding his election at least £25 in rates on ships or goods. A person to be a qualified elector must pay not less than £10 to the Board in the same manner. The members of the Board are unpaid and are mainly chosen by the Shipping and Trading Associations in Liverpool. Seven members of the Board retire annually, but are eligible for re-election.

The first troubles of the Board appeared at Birkenhead, where the dock construction had left much to be desired, the works having to be almost entirely reconstructed. However, this work was successfully undertaken by the son of Mr. Hartley, the old

Liverpool Dock Engineer, and under Mr. Hartley, Junr., and George Fosbery Lyster, and Anthony George Lyster, the famous Liverpool Dock Engineers who succeeded him, the West Float, the East Float and the Wallasey, Alfred and Vittoria Docks have been constructed on the Birkenhead side of the river. At Liverpool, among the Docks constructed by the Mersey Docks and Harbour Board, have been the Canada Dock and Canada Branch Docks Nos. 1, 2 and 3, the Huskisson Branch Docks Nos. 1, 2 and 3, the Brocklebank Dock and Brocklebank Branch Dock, the North and South Carriers, Herculaneum, Prince's Half-Tide, East and West Waterloo, Langton and Langton Branch, Alexandra and Alexandra Branches Nos. 1, 2 and 3, Harrington, Hornby, Sandon Half-Tide, Queen's Branch Docks Nos. 1 and 2, and King's Docks Nos. 1 and 2, while the Gladstone System of Docks is now in course of completion.

To describe in detail the gradual growth of the Liverpool and Birkenhead Docks and the trade of the Port under the Mersey Docks and Harbour Board since 1857 is the work of a historian, but a rough-and-ready idea of the development of the Dock Estate during this period can be gained from a comparison of the total water area and the lineal quayage of the Docks in 1858 with those of the present day. In the former year the water area was 199 acres against 600 acres to-day, while the quayage has increased from 15½ to nearly 37 miles. During this period, also, many of the older docks have been remodelled and modernised. The size of the average modern vessel is very much larger than that of the average ship of 1858, and the constant increase in the size of ships has necessitated the provision of larger docks with wide dock entrances from time to time and the widening of the existing dock entrances; this latter, although the policy of the Mersey Docks and Harbour Board has consistently been to construct their docks on a greater scale than actually required at the time of construction. For example, in 1891, when one of the largest extension schemes was

started, the largest vessel afloat was the 'Teutonic,' 565 feet long and 9,984 tons gross, but the docks included in this scheme have accommodated the "Mauretania," 762 feet long and 30,700 tons gross, and many other vessels of but slightly smaller dimensions. Another example is the Gladstone Graving Dock, the largest Graving Dock in Europe and the first commissioned dock of the system now in course of completion. When the Gladstone Dock Scheme was approved in 1906, the largest vessel afloat was the "Baltic," 709 feet long and 23,876 gross tonnage. Yet the Dock Board built their new Graving Dock 1,050 feet long, and it has already—it was opened in 1913—been used by a vessel 907 feet in length. The same policy has been followed, but to a more marked extent, in the construction of the entrance locks to the various docks, as is shown by the following three typical instances:—

	Date.	Width. ft.	Depth below O. D. S. ft.	Largest ship at date of dock design.	Largest ship dock entrance was designed to accommodate—
Langton Dock River Entrance	1879	65	12	4,500	10,000
Sandon Half-Tide Dock River Entrance	1901	100	20	10,000	30,000
Gladstone Dock River Entrance...	—	130	30	24,000	60,000

Reference has already been made to the Gladstone Docks. This system of Docks, the construction of which is now well in hand, is situated at the extreme north end of the existing Liverpool Docks, and will consist of a Vestibule Dock, two Branch Docks, and the existing Gladstone Graving Dock. A feature of this system will be the river entrance with its lock 1,070 feet long by 130 feet wide, and its sill 20 feet below

Liverpool Bay Datum (*i.e.*, 30 feet below the Liverpool 'Old Dock Sill'). The advantages to be derived from this gigantic lock perhaps will be appreciated best when it is explained that, except for a few hours at or near to the time of 'dead low' water of exceptional Spring Tides, it will be possible to 'lock in' large vessels of 28 feet draught of water at any time of the day or night—truly a remarkable feat at a river where the tidal range may amount to more than 30 feet. The new system will also be linked up with the existing Docks in order that vessels may be passed when required from the other Docks into it or to the Gladstone Graving Dock without having to go into the river. The quays at the new Docks will be equipped with modern treble-storey sheds, high-power electric cranes for unloading cargo, etc. and will have facilities for the removal of importations both by rail and road.

The majority of the Liverpool Dock berths have been provided with facilities for the removal or reception of traffic by rail, those not so equipped being almost exclusively allotted to vessels carrying cargo for distribution by road. The haulage of the railway wagons between the railway goods stations and the shipping berths at Liverpool is performed by the locomotive engines of the Mersey Docks and Harbour Board subject to a small charge.

A considerable proportion of the imports at Liverpool are intended for distribution or warehouse at distances within easy road access of the Port, and these imports are removed direct by motor or cart from the Dock Quays, while a large proportion of the export traffic of the Port is also brought to the Docks in the same manner. The quay system at Liverpool is so elastic that goods may be removed either direct from stowage on quay or direct from ship instead of having to be stored in sheds or warehouses on the quays, as is the practice at certain other ports. The Dock quay sheds have been built for the handling and transit of cargo and not as warehouses, and their construction

on these lines has proved beneficial in handling road-borne cargo which is now much on the increase

The Stanley Dock Tobacco Warehouse, with its thirteen floors (containing no less than 36 acres) and accommodation for 70,000 hogsheads, is probably the most up-to-date and largest warehouse of its kind in the world. Some idea of the size of this warehouse may be obtained when it is stated that it is 725 feet long, 165 feet broad, and about 125 feet high from the street level, has a basement, quay floor, and twelve upper floors, and required 27 million bricks and 6,000 tons of iron in its construction. It is served with quick-running lifts, and is of first-class fire-proof character.

The total warehouse accommodation actually belonging to the Mersey Docks and Harbour Board may be assessed at:—

Grain	60,000 tons
Tobacco	95,000 ,,
General Produce	70,000 ,,
East India Wool	150,000 bales
Colonial Wool	86,000 ,,

while other storage in the Port will accommodate:—

Grain	200,000 tons
General Produce	1,600,000 ,,

Incidentally, the Mersey Port is the second largest milling centre in the world.

The quays at Liverpool are something approaching 37 miles in length, but reliance has not been placed on them to afford adequate embarking and disembarking facilities for passengers, a landing-stage, some 2,500 feet long by 80 feet wide, having been provided which rises and falls with the tide, so that passengers to and from liners, steam tenders, or cross-river ferry boats may pass to and from their vessels at any state of the tide. This landing-stage is situate adjacent to the heart of the city and is connected with the shore by ten bridges and by a floating roadway of 550 feet in length and 33 feet in width, on which motor and cart traffic is afforded an easy incline at all times of the tide, while alongside the stage is the Riverside Railway

Station where passengers entrain or detrain to and from all parts of the United Kingdom. On the stage itself, which has recently been brought up to date, everything conceivable has been provided for the comfort of the ocean traveller, including such conveniences as waiting-rooms, covered passages leading the whole length of the stage, covered gangways to liners berthed alongside, a post office, baggage conveyors, etc., and such necessities as a police station, Customs baggage examination rooms, a Government emigration station, etc.

It is very difficult to prophesy the future of a great port such as Liverpool, dependent as it is on the requirements of that industrial England which it serves, but it is unlikely that industrial England will be able to ask anything of the Port of Liverpool which the Port will be unable to provide. Thanks to the foresight of the Mersey Docks and Harbour Board in the past, the Board have ample space at their disposal for future dock construction both in Liverpool and Birkenhead. The most valuable of these available spaces is that at the North end of the Liverpool Docks, as it is here that the deepest water is available.

SHIPBUILDING AND SHIP REPAIRING.

G. H. Potter
(Chairman, Messrs. H. & C. Grayson, Ltd).

In an important centre like Liverpool, whose existence and expansion depend largely upon the overseas trade, shipbuilding and ship repairing, and more particularly the latter, must always play an important part.

The immense amount of tonnage cleared inwards and outwards at the Port of Liverpool during the year conveys some idea of the large number of vessels which have to be examined and repaired and kept in order for their varied trades, and apart from repair of damages occasioned by stress of weather and other causes of maritime disasters, the general upkeep and making good of ordinary wear and tear employs a large number of mechanics of all classes in this Port, the number of vessels entering the Port during 192[illegible] being over 16,000, with a tonnage of more than 15,000,000; the number of vessels using the Graving Docks of the Mersey Docks and Harbour Board during this period being about 900, in addition to vessels using the Graving Docks of private Companies being some 300 more.

In addition to the 22 Graving Docks provided by the Mersey Docks and Harbour Board, private enterprise has also added largely to the number, and the total number of Graving Docks, the larger ones capable of dealing with any class of vessel afloat, numbers altogether some 36.

In order to deal with work over the length of the Docks, which extend for many miles on both sides of the Mersey, the more enterprising firms have provided establishments adjacent to the various sections of dry-docks, thereby reducing the cost of carrying out repairs

to a minimum as well as saving time in the transport of men and material between the works and the vessels under repair, so returning vessels to their trade without delay.

During the War the allocation of accommodation for vessels requiring the use of dry-docks was largely in the hands of the Directorate of Ship Repairs, and in the two years that this control existed some 3,700 vessels were dealt with by that department alone, these being independent of vessels whose repair was not a concern of the department in question, and which did not require any lengthy accommodation in dry-dock.

At the commencement of hostilities in the Great War, ship repairers anticipated the demands which would probably be made upon their resources, and at an early stage set about bringing their establishments to the highest pitch of perfection, and large sums of money were expended in the purchase of the most up-to-date tools and appliances, and the general extension of establishments to deal promptly with repairs of any class to vessels which might be placed in their hands.

In the extension and equipment of their several works none were more prominent than the old-established firm of H. and C. Grayson, Ltd., which is one of the oldest, as it is one of the largest of its kind in the world, having establishments at the North end of Liverpool at Canada Dock, at the South end at Queen's Dock, as well as the shipbuilding yard at Garston with its private Graving Dock, and in addition the two establishments in the Birkenhead system of Docks.

Messrs. Clover, Clayton and Company's works, now under the control of Messrs. H. and C. Grayson, Ltd., with their six private Graving Docks capable of dealing with vessels up to 570 feet in length, thoroughly equipped and the works entirely remodelled, combine to make a ship repairing establishment quite unique in its self-contained capacity and second to none in the kingdom in its equipment and general efficiency.

In addition to the above-named establishments, Messrs. Harland and Wolff, the famous Belfast shipbuilders, have established works at the North end of Liverpool, where they deal in their up-to-date works more particularly with vessels owned by the companies with which they are more intimately connected, and at the same end of the town, and more especially concerned with the work in the North system of Docks, are the well-laid-out and equipped works of Messrs. David Rollo and Sons, long famous as engine builders and also largely employed as ship repairers and iron founders.

In this Northern section of the town are also the works of Messrs. C. and H. Crichton, and several other establishments of less extensive character.

During the busy times of the War upwards of 30,000 men were engaged in the Port of Liverpool upon shipbuilding and ship repairs, of which number fully two-thirds were occupied in ship repairing as apart from new construction work.

At the Birkenhead side of the river are the shipbuilding yards and dry docks of Messrs. Cammell, Laird and Co., and, in addition to Messrs. Clover, Clayton and Co.'s works on the river side, are the two establishments of Messrs. H. and C. Grayson, Ltd., at the top end of the Float, the one in close proximity to the three Birkenhead Dry-docks and also the Slipways, with two slips capable of taking vessels up to 175 feet. There are also on the Cheshire side of the river the establishments of Messrs. Gordon Alison and Co., and Messrs. Rutherford and Co.

The above brief summary of the capacity of the Port as regards the ship repairing industry will indicate the importance of this accessory to the trade of Liverpool, an adjunct which is vital to the shipowning industry and general community of the Port, for as long as ships sail the sea the necessity for repair and upkeep will be ever present, and by preparing themselves to deal promptly with whatever is placed in their hands, the ship repairing industry has

contributed its quota to the maintenance of Liverpool as one of the foremost ports of the world.

Since the activities following the termination of the Great War, when the ship repairers of the Port were very fully occupied in reconditioning vessels and making good defects consequent upon the heavy demands made upon them, the trade of the Port has been in a depressed condition, and some unemployment has been caused owing to the vessels having been laid up in consequence of the reduced demand for tonnage, but signs are not wanting that the trade is on the eve of better times, and with the employment of more tonnage ship repairers may look forward with confidence to being busily employed in the early future.

CHEMICAL MANUFACTURES ON MERSEYSIDE.

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The following brief descriptions of the activities of some local firms are intended to convey (in so far as space permits) an idea of the manifold chemical operations carried out at the present day in the Merseyside district, together with some historical notes.

Alkali Industry.

It is of special interest from the standpoint of Chemical Industry that Liverpool should have been selected as the meeting-place of the British Association this year. Almost exactly one hundred years ago the manufacture of alkali was founded in Liverpool itself. This industry grew rapidly and formed a nucleus around which was developed a complex chain of other processes of various kinds. The centre of gravity of the majority of these was undoubtedly the parent alkali manufacture.

It is significant that the recently-celebrated centenary of the Alkali Industry, which all through its history has been intimately connected with this district, should coincide nearly with that of the British Association itself.

So closely has Liverpool been identified with the manufacture of alkali and kindred products that it might be described as the headquarters of the Heavy Chemical Industry.

Although this industry is of such outstanding importance in the vaguely-defined area of Merseyside, it must not be supposed that it is the only form of chemical activity that flourishes in the district. Even on the banks of the Mersey in the more literal sense, so diverse are the chemical manufactures carried on that it is impossible in an article of this kind to do more than mention some of these operations.

The manner in which a large number of the local industries have grown up will perhaps be made clearer by a short historical survey of the Alkali Industry to which many of them owe their existence.

At the end of the eighteenth century several works in different parts of the country were engaged in the manufacture of sulphuric acid and bleaching powder on a small scale. The latter product was patented by Tennant in 1798, and it gradually replaced the much slower sun-bleaching process.

In the year 1822, Muspratt erected a vitriol plant in Liverpool, and this works soon became famous. The salt tax was repealed in 1823, and Muspratt lost no time in using this opportunity for working Leblanc's process which had proved to be unremunerative before. When Leblanc brought out his process the salt tax in this country was £10 per ton, which was increased to £30 during the Napoleonic Wars.

In this undertaking he was at first successful, but serious difficulties soon arose owing to the nuisance caused by large quantities of hydrochloric acid which were allowed to escape. Many law-suits resulted, and Muspratt was compelled to transfer his operations to Newton in Lancashire.

Eventually this problem was solved in 1836 by Gossage, who constructed a tower for absorbing the acid fumes. In this way he not only eliminated the trouble caused by the acid but secured at the same time a valuable by-product. The hydrochloric acid solution obtained by use of the towers was consumed later in the galvanised iron trade, for gelatine manufacture,

and in the dye industry, though the greater part of it was used for making bleach-powder.

Alkali works were started at St. Helens by Muspratt, Gamble, Crosfield and others between 1823 and 1836, and as the result of the successful working of the Leblanc process, the price of soda, which was £60 per ton in 1800, fell to below £20.

In the year 1838 two important events occurred, which had later on a far-reaching influence on the Leblanc process. One was the restriction imposed on the export of sulphur from Sicily. This led to the production of sulphur dioxide for the manufacture of sulphuric acid by roasting iron pyrites obtained from Spain. The other landmark was the patenting of the ammonia soda process by Dyar and Hemming. In spite of the numerous attempts made by the inventors of the process, and by Muspratt, Deacon, and others in this country, success was not obtained until Solway worked out the necessary conditions in 1861. The process was introduced in this country by Mond at the works of Messrs. Brunner, Mond and Co., Ltd., and before long the Leblanc process appeared to be doomed.

Although the supply of hydrochloric acid became plentiful after the Gossage absorption-tower came into general use, the manufacture of 'bleach' was still costly owing to the waste of manganese in the generation of chlorine. The introduction of the familiar Weldon process, for recovering manganese, at Gamble's Works at St. Helens, in 1866, resulted in a reduction of the price of bleaching powder to about £6 per ton.

Deacon's process, worked out in Widnes in 1868, became a serious competitor with that of Weldon since it eliminated the loss of chlorine as calcium chloride, but it suffered from the disadvantage of producing a much more dilute gas than was obtained in Weldon's process. These advances in the methods for chlorine generation benefited the consumers of 'bleach,' notably the textile industry.

Just as the absorption of hydrochloric acid resulted in a two-fold improvement in the Leblanc process, so

also was the case when the recovery of sulphur was successfully accomplished.

Prior to this the calcium sulphide, or 'alkali-waste,' obtained as a by-product was dumped on waste ground surrounding the works. Due to the gradual liberation of sulphuretted hydrogen from this material the neighbourhood suffered nearly as much as when hydrochloric acid fumes were allowed to escape.

Chance's process overcame this difficulty and provided a valuable source of pure sulphur for reconversion to sulphuric acid, etc., and by a later modification of Chance's process, supplies of photographic 'hypo' were also obtained from alkali waste.

Among the by-products obtained from the sulphuric acid plant run in connection with the Leblanc process, mention should be made of certain metals found in the cinders from the pyrites burners. A process was worked out by Henderson for obtaining copper in paying quantities along with small amounts of silver and gold from this source.

Arsenic and selenium were recovered from the flues of the pyrites burners. It should be noted here that these elements find application in various industries. Arsenic is used in the manufacture of certain kinds of alloys, glasses, and glazes as well as in making insecticides for spraying fruit trees. Selenium is employed to some extent commercially owing to its valuable property of showing a great decrease in electrical resistance when light falls upon it.

Large fortunes were made in the Alkali Industry in its earlier days in spite of frequent law suits which went against the manufacturers. Conditions changed, however, soon after the introduction of the ammonia soda process in 1872 at the works of Messrs. Brunner, Mond and Co., Ltd., at Northwich.

This process led to such a reduction in the price of soda that the Leblanc method could only hold its own by reason of its valuable by-products, as distinct from the ammonia soda process, which yielded none.

Notwithstanding these advantages, manufacturers using the Leblanc process found it more and more difficult to make it financially workable. It was this fact that led to the formation of the United Alkali Co., Ltd., in 1890.

Such a gigantic combine of some 48 works, in different parts of the British Isles, was only accomplished as the result of strenuous efforts. The interests involved were salt works and manufacture of 'bleach' and alkali by Leblanc's process. By controlling the price of 'bleach' and other products, the Union was able to prevent the threatened collapse of the old process, although difficulties were experienced in connection with patents and Excise regulations.

The industry was expanded in many directions, part of the policy of the new firm being to concentrate at a few centres, notably the Mersey, Clyde and Tyne. Later on pyrites mines in Spain were acquired, larger salt and limestone deposits made available, and the ammonia soda and electrolytic processes for alkali manufacture were also adopted.

The production of organic chemicals was developed, the earlier efforts being directed to acetic acid, acetone, chloroform, benzene and its chlorination products, whilst at the present time a large variety of dye-intermediates and fine chemicals are manufactured.

Each extension of the business tended to link the alkali- with other industries. The uses to which recovered sulphur can be put is a case in point. The production of black gunpowder is, of course, of relatively less importance than formerly, but it is still made for certain purposes. Large quantities of sulphur are consumed in the rubber industry and, in the form of bisulphites, for treating wood pulp in the manufacture of paper and artificial silk. Sulphur is also used in the match industry, for bleaching purposes, and in the production of ultramarine for laundries.

In the preceding account stress has been laid on the vastness of the field which scientific research has linked

up with the alkali industry through the by-products obtained in the Leblanc process. As far as the use of alkali itself is concerned one would have difficulty in finding many industries which are independent of it. Alkali is, of course, essential for the manufacture of soap, glass, enamels, glazes, porcelain, ultramarine, water-glass, paper, baking-powder, etc., and large quantities of it are consumed in cleansing operations of all kinds. The present extensive production of cyanide is dependent on supplies of alkali, as is also the extraction of chromium, tungsten, and molybdenum from their ores. These products control other industries, such as the extraction of gold by cyanide and the manufacture of special steels in which the metals chromium, tungsten and molybdenum are employed. The textile and dye industries are also large users of alkali.

During the war the United Alkali Co., Ltd., made alterations in their business to meet the special needs of the country, and although these developments were in some respects temporary, many interesting advances were accomplished.

Enormous quantities of sulphuric acid were made for the production of explosives, and indeed, the manufacture of the latter was undertaken at many of the Company's works. In this connection such materials as ammonium nitrate, acetone, nitric acid, benzene, toluene, and the nitrated derivatives of these two hydrocarbons may be cited as some of the munitions made by the Company.

The United Alkali Co., Ltd., was among the first to supply material for combating poison gas and for the manufacture of this weapon. Other notable efforts of the firm during the war were the production of fertilizers, especially for local allotment-holders, and not less important, disinfectant materials used in the Services.

The war brought about one result which will constitute a landmark in the history of alkali manufacture, and this was the final disappearance of the

Leblanc process. Although the last plant was not dismantled till 1920, it was the shortage of labour and the demand for sulphuric acid for other purposes during the war that hastened the end of the process which had held its own during more than a century.

Besides the United Alkali Co., Ltd., there are several firms around Merseyside where alkali is made in large quantities, whilst there are others which make sufficient only for their own needs.

Mention has already been made of Messrs. Brunner, Mond and Co., Ltd., in connection with the introduction of ammonia soda process in this country. The headquarters of this firm is at Middlewich, but this town is, strictly speaking, outside the field at present under review.

Another Merseyside firm that is specially associated with the most modern methods of alkali manufacture is Messrs. Castner, Kellner Alkali Co., Ltd. Ever since the Company's formation in 1895 the electrolytic decomposition of salt has been studied and developed on highly scientific lines.

A large amount of research had been directed to working out a commercial process for alkali manufacture by this method. Carl Kellner and Hamilton Castner, two pioneers in this field, patented a special cell in which the decomposition of salt was attained. About the same time Hargreaves and Bird brought out a different method, in which a cell made of porous material was used to allow diffusion of the soda formed to the outside. The latter process was worked by the Electrolytic Alkali Co., Ltd., and later taken over by the Electrolytic Bleach and By-Products, Ltd., at Middlewich.

The patent rights of Castner, Kellner and the Aluminium Company were merged and taken over by Messrs. Castner, Kellner Alkali Co., Ltd., and the construction of their works at Weston Point, Cheshire, began in 1896. The works are scientifically planned, and have been kept up to date, as may be judged by the changes which have been made in the power plant

employed. In 1897 vertical steam engines developing 1,000 h.p., were installed for generating current to be used in electrolysing brine. Later, when the power requirements increased, gas engines, supplied with gas from Mond producers, were substituted for the steam engines. With the improvements in modern steam turbines, the firm has still further developed their power plant in this direction.

Brine for electrolysis is supplied by pipe line from Northwich. Remarkably pure caustic soda is obtained in the process, and this product is sold in large quantities for soap making and for use in the textile trade.

At the Company's Tyne Works metallic sodium is made from caustic soda, a large proportion of which is converted to sodium peroxide at Weston Point. The latter product is used in the textile, silk and straw-plait industries. Sodium perborate is also manufactured and finds application in the soap, laundry and textile trades.

The chlorine and hydrogen, also produced during electrolysis of brine, are used for various purposes. Part of the output of these gases is converted to hydrochloric acid, whilst another part of the chlorine is used for making bleaching powder. The method adopted is a modified form of Hasenclever's process, the chlorination taking place in a series of tubes The product obtained is a white homogeneous powder containing 37 per cent. available chlorine.

Large quantities of the chlorine are liquefied, and transported to other works belonging to the Company for the production of certain organic chlorine compounds, for example, chlorbenzene, tetrachlorethane, trichlorethylene, etc. Cylinders of liquid chlorine are sold for other purposes, such as bleaching, sterilising drinking water, and treatment of effluents. Sodium chlorate, sodium hypochlorite, and calcium hypochlorite (known as 'chemic') are also made at the Company's works from electrolytic chlorine.

It was not mere chance that Castner, Kellner Alkali

Co., Ltd., were able to render such valuable service to the Government during the war. Since 1911 foreign manufacturers had been developing their works to be equally available for purposes of peace or war. This fact had decided the Directors of the Company to augment their output of certain products so that the extension of their works was just completed before the outbreak of war.

Adjoining the Castner, Kellner Works at Weston Point is one of the extensive works of the Salt Union, Ltd. In these works enormous quantities of salt are obtained by evaporating brine carried by pipe line from the great salt deposits of Cheshire.

The proximity of such an excellent seaport as Liverpool to these deposits has been of the utmost benefit in the development of the salt industry in this country, and, incidentally, has made Liverpool one of the most important salt distributing centres in the world.

The discovery of the Cheshire beds of rock salt was made in 1670, although salt had been obtained by the Romans from brine springs in this region. The beds occur in isolated areas, of which the principal are those in the neighbourhood of the towns Winsford and Northwich. In these areas two definite layers can be recognised; the top one of salt, about 80 feet thick lying at a depth of 120-130 feet below the surface, and the bottom bed of approximately similar thickness, separated by about 30 feet of hard marl from the top layer.

The composition of the natural rock salt varies according to the amount of admixed marl, but on the average contains 95 per cent. of sodium chloride.

Mining was largely resorted to formerly for winning the salt, but this method has almost entirely been replaced by brine pumping and evaporation. This procedure has the advantage of securing ready separation from insoluble impurities and ease of transport, which compensate for the cost of evaporation.

The evaporation of brine is carried out both by the open pan and the triple effect vacuum pan methods. In the former, rectangular pans constructed of riveted iron plates, directly heated by coal fires, are employed. The dimensions of the pans are about 20 feet wide, 2 feet deep, and from 40 to 100 feet long.

By varying the temperature of evaporation, and by supplying suitable addition-agents to the brine, differences in grain size of the salt are produced to suit different industrial uses—for example, 'fishery' salt with coarse grain, 'butter' salt with very fine and soft grain.

The second method, involving steam heating and the reduction of the vapour pressure above the brine, provides the most rapid and economical method of brine evaporation, but has the drawback of permitting very little control over the grain size of the salt produced.

A heavy traffic in water-craft carrying salt from Winsford (the largest manufacturing centre for 'open pan' salt in Cheshire) is maintained along the River Weaver. Connection with Liverpool is made *via* the Manchester Ship Canal and the River Mersey.

At Weston Point, however, direct loading of ocean-going ships with salt is facilitated by the situation of the vacuum evaporator plant of the Salt Union on the banks of the Manchester Ship Canal.

The three pans of this plant are 26 feet in diameter, 60 feet high, and have a production capacity of four to five thousand tons of salt per week. The brine-supply is pumped from Marbury, near Northwich, a distance of eleven miles.

An interesting development at Weston Point is the economic combination of electrical power production and salt manufacture, whereby the low-pressure exhaust steam from the turbines of an adjacent power station is utilised for heating the 'first-effect' in the vacuum plant.

The product of the direct evaporation of Cheshire brine contains on the average 98·5 per cent. sodium chloride, the remainder consists principally of calcium

sulphate (1 to 1·5 per cent.) and magnesium chloride (0·05 to 0·1 per cent.). In the production of salt for edible purposes where the highest possible purity is desirable, these small amounts of calcium and magnesium salts are removed from the brine at the Winsford Works of the Salt Union. Evaporation is then carried out in enclosed vacuum pans, and thereby a product is obtained, which is hygienically pure, and very little short of 100 per cent. sodium chloride.

The annual production of salt for the British Isles has been steadily maintained at about 2,000,000 tons for many years past, including the salt in brine which is used directly as such for chemical manufacture, amounting to about a quarter of the total production. It ranks fourth in order of output of British minerals that are mined, the first three being coal, iron ore and oil shale, and between 25 and 30 per cent. of the annual production of salt is exported. The importance of the Cheshire salt field may be gauged from the fact that over three-quarters of the whole output of the country comes from this region.

Phosphate-Fertilizers.

The phosphate works of Thomas Vickers and Sons, Ltd., is an old-established undertaking. In 1836 bone manure manufacture was started at Miles Platting, near Manchester, some time before the manufacture of superphosphate in this country. In 1873, owing to expansion of business, an additional works was erected at Widnes, on the banks of the Mersey, with loading accommodation for coasting steamers up to 600 tons. The Company's works at Miles Platting has recently been closed and the business concentrated at Widnes.

Within the last few years the whole of the manufacturing installation has been reorganised, steam power has been replaced by electricity, and mechanical contrivances have very largely displaced manual labour.

The most important product manufactured by the Company is superphosphate, which is supplied in three

grades varying from 30 to 35 per cent. water-soluble. Superphosphate, containing 4 per cent. of potash, is another product, known as 'potassic' superphosphate, which is particularly suitable for grass and clover in permanent pastures.

A large variety of special fertilisers are prepared for turnips, potatoes, fruit trees, corn, etc., and a guaranteed analysis is available for each. Another compound fertiliser produced by this firm is 'dissolved bone compound,' and, in addition to these special products, ordinary materials, such as bone meal, sulphate of ammonia, basic slag, lime, etc., are handled by the Company.

Other well-known firms in Liverpool are engaged in making similar products.

Smalt, Ultramarine and Glass.

The manufacture of smalt was established at Seacombe in 1819 by Mr. C. E. Rawlins, and was removed to Brook Works, Rainhill, near Liverpool, over eighty years ago, where it is still carried on by Rawlins and Son (Smalts), Ltd., the present directors being the grandsons of the founder.

Smalt is glass coloured blue by the presence of cobalt and ground to a fine powder. It's superiority over ultramarine as a blue pigment lies in the fact that it is a fast colour under practically any conditions, and is quite unaffected by acids, sunlight and exposure to air and moisture. It is used for the blueing and bleaching of the more expensive papers, such as those required for legal documents, ledgers, etc., and it also plays an important part as a bleacher of linen and lace. In Ceramics it is used for producing blue colourations and patterns, and is applied in glazing.

The uses of smalt have been largely diminished by its much cheaper rival, ultramarine; but for purposes where the fugitive nature of the latter, in presence of acids, renders it unsuitable, smalt is still employed.

The manufacture of ultramarine was established by Messrs. Rawlins and Son, at Rainhill, in the year 1868.

In 1891 the firm was converted into a Limited Company and the output of the factory quadrupled. In 1910 the factory was further enlarged, and the name of the Company was changed to Rawlins and Son (Ultramarine), Ltd.

The Company produces many different qualities of ultramarine, amongst them being those suitable for soap mottling, laundry blue, paint, paper-making, litho ink, bleaching and other purposes.

Ultramarine is the artificial form of the mineral Lapis Lazuli, and the methods of using it were discovered in 1828 by Guimet in France and Gmelin in Germany. In chemical constitution ultramarine is a double silicate of aluminium and sodium in association with sulphide of sodium. The raw materials employed in making it are mainly china clay (such as is found in Cornwall), soda ash, sulphur and infusorial earth, or other forms of silica. These are intimately mixed, ground and subjected to heat under suitable conditions, when ultramarine is formed. It is then finely ground, levigated (the different grades and qualities being thereby separated) and the settlements thus obtained are dried, sifted and blended to the required tints.

Just outside the district under consideration there is an important Glass-making Industry, where common window-glass, plate-glass and cathedral-glass are turned out in large quantities.

Carbon Dioxide.

The Washington Chemical Company, whose head-quarters is in Durham, erected a factory in Bootle over 20 years ago for the manufacture of pure carbon dioxide. The plant installed by this firm has been kept up to date, and they are now one of the largest manufacturers of carbon dioxide in the country.

Refrigeration plant and the manufacture of mineral waters consume most of the output of the Company, and great care is taken to obtain a pure and dry product suitable for these requirements. A large stock of seamless steel cylinders is kept for transporting the

gas. A special feature of these cylinders is a safety type of valve designed by the firm.

Sulphites, etc., Dyestuffs, Coal-Tar Products.

At Mersey Works (Port Rainbow, Cheshire) Messrs. Brotherton and Co., Ltd., have in operation the only plant in this country which is available for the manufacture of hydrosulphites by modern processes. The factory (which stands in a site of 40 acres on the left bank of the Mersey, near Bromborough Port) formerly belonged to a combination of important German colour firms and was purchased from the Board of Trade in 1917 as enemy property.

Synthetic Dyestuffs, Mordants, and Formaldehyde Sulphoxylates (Formosul) are amongst the products manufactured by the present owners of the works.

Messrs. Brotherton now run their Litherland Works as a Tar Distillery, as in pre-war days; though, during the war, it was a Government factory for the manufacture of T.N.T.

The products at present manufactured are Benzol, Toluol, Solvent Naphtha, Cresylic Acid, Carbolic Acid, Creosote, Naphthalene, Anthracene, Pitch, Refined Tar. The raw material is, of course, the Crude Tar from Gas Works.

Messrs. E. Bramwell and Sons, Ltd., undertake the manufacture of Sulphite of Soda, Epsom Salts, Hyposulphite and Sulphide of Soda, in their works at St. Helens, Lancashire.

The British Dyestuffs Corporation, Ltd., have a large branch works for making Vat Dyes, etc., at Ellesmere Port, Cheshire.

Soap, Glycerine and the Hardening of Oils.

Under this heading some indication is attempted of the complex industry controlled by Lever Bros., Ltd., in their great works at Port Sunlight. Here, on March 3rd, 1888, the manufacture of Sunlight Soap was established after having been successfully worked out at Warrington from the year 1886 onwards.

Since those early days the simple process of boiling fats with caustic alkalies has been continually improved, and extensive research has been directed towards production of reagents, recovery of by-products and new uses for the same, until at the present time a large number of chemical operations are bound up with the scientific production of soap.

The trained chemist in the laboratory and the engineer in the works have played an indispensable part in this great development, and it is of interest to note one or two directions in which outstanding results have been achieved.

Caustic soda used for saponifying the oils and fats is manufactured by two processes, viz. :—

(1) The Lime process.
(2) The Ferrite process.

The former is conducted in open pans which are steam-heated and have mechanical stirrers. Each pan also carries two or three cages into which lime is dumped. Soda ash solution is pumped into the pans and the agitators are set in motion: the lime is thus continually washed with sodium carbonate solution, and the more dilute the original solution is, the higher the percentage conversion into caustic soda.

In practice a limit is set to the dilution by the necessity of subsequently evaporating the dilute caustic lyes. After settling out the precipitated calcium carbonate, the liquor is concentrated in ' triple effect ' evaporators to a suitable specific gravity or strength for soap-making.

By the Ferrite process soda-ash is roasted at a red heat in ' revolver ' furnaces with ferric oxide, whereby sodium ferrite is produced with evolution of carbon dioxide. The molten ferrite is lixiviated with water when it undergoes hydrolysis with formation of a concentrated solution of caustic soda and regenerates ferric oxide, which can be used over again.

The lyes obtained in the soap-making process by boiling glycerides with caustic soda solution in an open

pan contain all the glycerol which the oils and fats employed are capable of yielding.

After removal of the fatty and other organic impurities, the lyes are concentrated up to about 80 per cent. strength of glycerol in evaporators, which remove the common salt as it separates.

Distillation in steam at 190° C. gives weak glycerine, or 'sweet waters,' containing 10 per cent. of glycerol, which is re-concentrated in vacuum pans to a sp. gr. of 1·262 (equivalent to over 98 per cent. glycerol); this product is mostly used in the manufacture of high explosives, such as cordite, dynamite, etc.

For pharmaceutical and dietetic purposes, the distilled glycerine referred to above is treated with animal charcoal and subjected to a second distillation, which gives a chemically pure glycerine with minute traces of water.

Hydrogen employed in the hardening of oils is manufactured by the two following methods:—

(1) The Electrolytic process.

(2) The Steam-Iron process.

The first process consists in electrolysing aqueous solutions of caustic soda in a series of cells, whereby hydrogen and oxygen are evolved and collected separately. To obviate, as far as possible, the contamination of hydrogen with oxygen, whereby an explosive mixture might be formed, porous diaphragms are introduced between the electrodes.

Small traces of oxygen, still remaining in the hydrogen, are removed by combustion over a suitable contact surface; the final product being exceptionally pure, is eminently suitable for use in catalytic reactions.

Production of electrolytic hydrogen commercially is bound up with the demand for oxygen, as apart from the latter consideration, the cost of power in this country is such as to render this method of manufacturing hydrogen uneconomical.

The Steam-Iron process involves first of all the

manufacture of water-gas, which is carried out by alternately passing air and steam over red-hot coke in a suitable generator.

During the passage of air, part of the carbon is oxidized to carbon dioxide together with some carbon monoxide, reactions which are exothermic, *i.e.*, which generate heat. The operation is known technically as the 'Blow,' and for successful working the aim is to bring about, as far as possible, the first of these reactions, since it is accompanied by the evolution of a much larger quantity of heat than the second.

The operation of passing steam over the coke, which has stored up the heat evolved during the 'Blow,' is referred to as the 'Run,' and affords a mixture of carbon monoxide and hydrogen known as water-gas. In addition to these two gases, the water-gas may contain up to 8 per cent. of other gases (principally carbon dioxide and nitrogen) as impurities.

Conversion of water-gas into hydrogen is effected in two stages. The gas is caused to reduce iron oxide heated to about 700-800° C. in suitable retorts, and the metallic iron thus formed is acted upon by steam, whereby hydrogen is produced.

Theoretically each volume of water-gas yields one volume of hydrogen, but in practice the retorts are heated by means of 'spent' water-gas (which has passed through the retorts), so that the actual ratio of water-gas used to hydrogen produced is generally about $2\frac{1}{2}$ volumes to one. The hydrogen needs careful purification from carbon dioxide, carbon monoxide, sulphur compounds, etc., before it can be employed for catalytic purposes.

Pure hydrogen, produced by either or both of the processes described above, is employed for 'fat-hardening' or the catalytic addition of hydrogen to unsaturated glycerides in the presence of finely-divided nickel.

The catalyst is prepared by precipitating nickel hydroxide or carbonate upon an inorganic support, and reducing to metallic nickel at about 350° C. A

small quantity of this catalyst is mixed with the oil to be treated, and the mixture subjected, at 160-200° C., to the action of hydrogen at about 10 atmospheres pressure.

By the use of one part of nickel to a thousand parts of oil a liquid, such as whale oil, which is unsuitable for soap-making purposes on account of its consistency, smell and colour, is converted in two hours or so into a solid white fat, which has no trace of fishy smell. This can now replace, to a considerable extent, tallow and other hard fats used in soap-making.

As in other catalytic processes, great care must be taken to eliminate 'catalyst-poisons' both from the oil and from the hydrogen, so that it is necessary in practice to refine the former and purify the latter before the operation of hardening is carried out. The presence of even small traces of injurious impurities would impair the activity of the nickel to such an extent that the 'hardening' would be either inhibited altogether or enormously retarded.

One of the largest businesses of its kind in the world is that of Messrs. Joseph Crosfield and Sons, Ltd. (founded in 1815).

Besides making all kinds and varieties of Soap, they are producers of Carbosil, Persil, Caustic Soda, Silicate of Soda, Glycerine, Portland Cement, Edible Fats, etc.

The works occupy positions on both sides of the River Mersey, whilst the firm have their own fleet of steamboats and are connected with three leading railways through their network of private sidings and lines.

Manufacturing processes in the various stages are carried out under expert scientific control, the raw materials and finished products being especially subjected to close examination in order that the highest degree of quality and uniformity may be maintained.

Continuous research is being carried on with a view

to improving existing processes and developing new ones.

An entirely new building has been constructed recently upon the most up-to-date principles devoted to housing the plant of the firm's subsidiary, the Erasmic Company, Ltd., which manufactures the well-known Erasmic Toilet Soaps, Perfumes and Specialities.

The above outline of the activities of one great firm must suffice as an example, but it should be mentioned here that many others in this district are engaged in kindred industries, *e.g.*, seed-crushing, the extraction and refining of vegetable oils for edible and other purposes, and the refining and blending of mineral oils for use as fuel, illuminants and lubricants.

Candle Manufacture.

A branch of Price's Patent Candle Co., of London, has been established on the banks of the Mersey for over seventy years. Whilst Chevreul (the great French chemist) was the discoverer of fatty acids and their uses for candle-making, the credit of placing the invention on a substantial manufacturing basis belongs to England. The experiments of Wilson and Jones on the preparation of white, inodorous candle-making material from palm oil and other inexpensive crude fats by acidification with sulphuric acid and subsequent distillation were patented on behalf of E. Price and Co. (afterwards Price's Patent Candle Co., Ltd.).

The business has expanded until there are now five overseas branches in South America, South Africa, and China, not to mention several associated concerns in London and environs.

The Bromborough Pool branch comprises an estate of over sixty acres on the Cheshire side of the river. Here are extensive works and a model village, representing a successful pioneer attempt to associate with industry the social well-being of the worker.

Continuous improvements have been effected in the processes of candle manufacture, whilst the output,

which from 1847 to 1851 totalled 15,000 tons, has increased to a vast extent.

Not the least interesting phase of latter-day developments has been the adaptation of various oils with a view to utilising them in the manufacture of candles suitable for extreme climates; new processes have made possible the hardening of the candle and greater economy in use.

To Price's fell the honour of adapting, in its earliest stages, the invention of Cambacères, the plaited wick that eliminates the necessity for snuffing the candle. No less important is the firm's record in utilising by-products of candle-manufacture (*e.g.*, oleic acid and glycerine) for commercial needs.

The growth in the popularity of the paraffin wax candle, an elegant and economical article, lent a stimulus to the production and import of solid paraffin: and of the enormous output of the United States, Scotland, Burmah, Java and Galicia, by far the largest portion of solid paraffin exported finds its way in normal times to this country, much of it being prepared for candle manufactures on the banks of the Mersey.

Tanning and Tanning Materials.

In their extensive works at Runcorn, the Highfield Tanning Co., Ltd., carry out the interesting chain of processes by which raw hides are converted into leather.

The hides are first sorted into different classes, and these receive suitable modification in the subsequent treatment according to the nature of the finished product required.

In the 'Lime House' the hair and flesh are taken from the hide, which is thereby left clean ready for going into the tanning process.

By the action of vegetable 'tans' the prepared hides are permeated with substances which give 'body' and toughness to the animal tissue with final production of the various grades of leather.

Drying and preparation for the market are necessary before the product becomes a finished article. It is noteworthy that the ravages of pest and disease, particularly from the warble and tsetse flies, upon animals cause great difficulties in handling the hides for leather.

The Calder and Mersey Extract Co., Ltd., Ditton, Widnes, claim to be the pioneers in the manufacture of Vegetable and Mineral Tanning Extracts, Synthetic Tannins and Oils required in the Leather Industry.

It is more than a quarter of a century since tanners first began to use their materials in the form of concentrated extracts, and development of the Calder and Mersey Company has proceeded until its warehouses accommodate large stocks of raw tanning materials which are dealt with by the best available modern plant.

Spent tanning materials serve as fuel to provide low-cost power for the electrically-driven machinery and for lighting, and waste steam is utilised for the evaporation of tanning extracts. Both raw materials and finished products are carefully tested by a competent staff of chemists, thus ensuring uniformity and regularity of strength and high quality of the firm's commodities.

Research work is provided for in special laboratories, and a small experimental extract-factory with tanyard have been installed to 'try-out' new materials and blends.

The Company have at least a dozen special technical products on the market.

Gum Tragacanth, etc.

At Hooton, in the Wirral Peninsula, the Gum Tragasol Supply Co., Ltd., manufacture mucilaginous products from various tropical seeds.

These products find application in many ways in different industries, *e.g.*, Textiles (Fixing of Yarns, Finishing of Fabrics, Calico Printing Pastes, Wool

Creams), Leather (Tanning, Finishing, Fat Liquors), Pharmaceutical (Toilet Creams, Emulsions).

In conclusion, it should be stated that there exist many local industries and manufactures of a more or less chemical nature which, for the sake of brevity, cannot be more than mentioned here, *e.g.*: Pharmaceutical preparations (Messrs. Evans, Sons, Lescher and Webb, Ltd.; Messrs. Ayrton, Saunders and Co., Ltd.), Lactose manufacture (Works at Haslington, Crewe), Artificial Silk industry (Messrs. Courtauld, Ltd., Viscose Works, Flint), Copper Salts (Messrs. Dennis and Co., Widnes), Copper Smelting and Refining (Messrs. Bibby, Garston; Messrs. Vivian and Co., Liverpool), Iron and Steel Smelting (Shotton Iron Works), Refining of Acids and Chemical Reagents (Messrs. J. H. and S. Johnson, Liverpool; Messrs. J. W. Towers and Co., Ltd., Widnes).

MILLING INDUSTRY.

G. J. S. Broomhall, F.S.S.

Although the early history of Liverpool's Corn Mills is shrouded in an obscurity which even the patience and genius for research of the late Richard Bennett could not altogether dispel, we have within our reach, principally through the endeavours of this historian, some very interesting facts and details in connection therewith.

Up to comparatively recent years, the exclusive right of grinding corn in Liverpool belonged to the King and several privileged families. To quote from Mr. Bennett's book, 'Kings and Queens, Earls and Dukes of Lancaster, the Stanleys, Molyneuxs, Mores, Crosses, and many another of the old Liverpool families, as well as the Corporation, have in their turn, owned and worked Liverpool mills and bound the citizens under heavy penalties to grind their breadstuffs for them.'

Earliest records show that at one time the mills of Liverpool were held conjointly by the crown and the Derby family. But in 1629 Charles 1st alienated his ancient inheritance in Liverpool and the Royal 'soke' passed into the hands of one or two private families. Gradually, however, the legal rights of the 'soke' were taken away, chiefly through the instrumentality of the Corporation, until at last they were destroyed altogether.

First records of mills in Liverpool date back to 1257, when there is mention of two watermills and one windmill. These three mills were the private property of the Earl of Derby, by whom they were leased out. Picton and Bennett suggest they were situated on the declivity of the heath outside of the present Christian Street, Richmond Row, Byrom Street, etc., from which

the upper reach of the stream from Moss Lake Fields ran on its way to the Pool. In the immediate vicinity were Kirkdale Windmill, Bootle Watermill, Spellow Windmill, Skelmersdale Watermill, and the Liverpool Rural Windmills of Accers, Wavertree and West Derby.

The Watermills near Christian Street, known as the 'Eastham' or 'Eastown' Watermills, were succeeded by a windmill, and till the 18th century the neighbourhood remained the site for most of the windmills of the town. Among the more famous mills outside the Eastham area were the 'Middle Mill,' owned by the Crosse family, and the 'Townsend Mill,' which belonged to the Mores.

So much with regard to the earliest conditions of milling in Liverpool. Till the advent of the 19th century, no attempt had been made to supply more than the needs of the town. However, the great increase in the population of Lancashire and the adjoining counties, which took place between 1800 and 1870, resulting in a corresponding increase in the demand for flour, literally forced Liverpool to broaden its milling activities. More flour was wanted; where was it to be obtained? All-English wheat flour could not be produced in sufficient quanties, and, moreover, in years of a bad harvest, it was altogether too dear and unpalatable.

There was only one alternative, and that was to bring in supplies from overseas. Accordingly, large quantities of Irish and foreign wheat and flour were imported, and Liverpool immediately assumed great importance as an importing and distributing centre. Quite naturally, a keen competition sprang up in Liverpool between importers of foreign flour and millers. For some considerable time foreign flour, particularly Austro-Hungarian, more than held its own, this being due to the superior manufacturing methods employed abroad. The most successful of these methods, and the one which was the foundation of Liverpool's prosperity as a milling centre, on its adoption here, was that known as the roller system.

Roller milling was first introduced by Friedrich Wegmann in Austro-Hungary about the year 1820. The system consisted of large frames containing sets of fluted rolls, with inclined sieves sifting between each pair of rollers.

The success attending the sale in Hungary of high-class flour, induced several enterprising British millers to attempt its manufacture in England. The result was the erection, in about the year 1870, at Liverpool and other places of several plants on the Hungarian system. It is a fact of particular interest that the first plant to produce flour in this country without the aid of millstones was erected in Liverpool. These roller plants were not at once a great success. The machinery proved to be only suitable for certain classes of wheat, and as a consequence only a very small percentage of high-class flour could be produced. Later, other Continental systems were introduced; but the most successful systems were those designed and made by British firms, and these are generally in use to-day.

The ultimate success of the roller system enabled Liverpool millers to defeat their foreign competitors, and when war broke out in 1914, only a negligible quantity of foreign flour was being imported into this port. The war, however, gave a sharp impetus to the imported flour trade. In 1916 and 1917 the submarine campaign was threatening the very existence of our Mercantile Marine, and the necessity of economising tonnage space was strongly realised by the Government, who had complete control of the trade. In this connection flour had a considerable advantage over the more bulky wheat, and consequently was given an increasing preference. In 1918, the last year of the war, over 3½ million sacks of foreign flour were imported into Liverpool, and in the previous year nearly 1½ million. Since 1918, flour imports have fallen again, and in 1922 were actually lower than in the years immediately preceding the outbreak of hostilities.

It was a slow march from the primitive hand-pounding of grain to grinding by means of an upper and nether stone. Many centuries intervened also between the driving of these millstones by means of slaves and oxen and the harnessing of wind and water for the purpose, whilst there was a great space of time between the latter and the steam-driven mills. About a hundred years after the use of steam, however, the whole system of milling was changed.

The day of the windmill is not so far distant, however, as to be beyond living memory, but no proper comparison can be made between that and the present-day method of flour milling. The flour mill of the present day is so far an advance upon the stone mill of fifty years since that, except for the fact that flour emerged from each, there is little association between them. The floors of a large Port mill, on which scores of highly-intricate machines are situate, is a labyrinth of spouts. The process of reducing wheat to flour is now an intricate art, in which engineers, scientists, and men trained in the technical side of the business find ample scope for the exercise of their ability and genius.

At a large Port mill, such as one of those on the Mersey, the steamer carrying the wheat comes right up to the quay-side. By means of pneumatic suction, the wheat is transferred from the hold of the vessel to an automatic weigher, where it is weighed in its dirty state. It is then dry cleaned, and again weighed. Then it is taken to the silos. From the latter it is moved by conveyor-bands as required to the screen-room, where it is thoroughly washed and conditioned. At a mill of this character American, Canadian, Indian, Australian, Persian, Argentine and (when available) Russian wheats are received. Each kind of wheat differs in moisture content, and the quantity of dirt and other foreign substances varies considerably. When the washing process is completed, not only has each variety been brought to a uniform condition as regards moisture content and other things, but a

strange medley of foreign substances has been separated from the grain. Apart from the sticks, straws, stones, hard lumps of dirt, and all sorts of other things, such things as cockle, barley and oats have also to be separated from the wheat, which is done by a special machine or machines, or the flour made will be discoloured.

Not until all this has been done, not until the wheat is quite clean and uniform, does the first cracking of the berry take place. The object at this stage is to make as little flour as possible. The germ is removed because of its oily nature, and the bran is flaked off. The product in its several stages passes from machine to machine, from floor to floor, is constantly sieved and aspirated, and cracked again and again, until only the pure endosperm, or flour, reduced to the state in which the baker requires it, is left. It would require a whole volume to describe these processes in detail, and then it would be incomplete. Nor could the visitor to a flour mill unacquainted with the intricacies of the mill, hope at one visit to follow the 'flow' of the grain and the products from machine to machine and floor to floor. It has been computed that a grain of wheat travels a distance of two miles between the time it enters a mill and the time it leaves in the form of flour.

All this may seem extraordinary, but it serves to illustrate, not only the intricacies of flour milling, but the efforts which have been made to arrive at a perfect system, as measured by the ultimate product. The flour made to-day is better and purer than it has even been. It is dealt with automatically from the time the grain is received into the mill until the bags of flour are loaded on to the lorries or steamers for despatch. There is no man-handling anywhere, and thus the British miller turns out a product which has no superior, and the last, if not the least, wonder is that the finished product is sold to the consumer at a price which leaves only an infinitesmal profit to the miller for all his labour.

It is interesting to note that the present Lord Mayor of Liverpool is Chairman of the firm of W. O. and J. Wilson, Limited, and one of the Joint Managing Directors of the North Shore Mills Company—two of the oldest milling firms in this district.

THE GEOLOGY OF THE COUNTRY AROUND LIVERPOOL.

W. Hewitt, B.Sc., Assoc. R.S.M.

The geological character of the Merseyside area whose physiographical features have been described in an earlier article in this volume is not very greatly varied or complicated.*

In his article on the geology of the district contained in the Handbook prepared for the Meeting of the British Association in Liverpool, 1896, Mr. Morton gives a 'Vertical Section of the Geological Formations

* It is described in detail in the *Geology of the Country around Liverpool*, by the late G. H. Morton, the second and standard edition of which was published in 1891 : a supplement issued in 1897 being afterwards added to the volume. A great amount of detailed information, on special questions and localities is contained in the annual volumes of the *Proceedings of the Liverpool Geological Society* ; and a summary of the work of the Society and its history to date was published on the occasion of the Society's Jubilee in 1909-10, under the title, *The Liverpool Geological Society : A Retrospect of Fifty Years' Existence and Work.*

The *Geological Survey Maps* concerned with the area, both for the solid geology and for the drift, are as follows :

79 N.E. Liverpool, N. Wirral and N. Flintshire.
79 S.E. Central Wirral and E. Denbigh and Flintshire.
80 N.W. S.W. Lancashire, Liverpool to Warrington.
80 S.W. Chester, and Eastern Wirral to Frodsham.
89 S.W. Ormskirk to Wigan.
90 S.E. Liverpool to Southport.

Geological Survey Memoirs dealing with portions of the district are :
Geology of the Country around Wigan, by E. Hull, F.G.S., 1860.
The Superficial Geology of the Country adjoining the coasts of S.W. Lancashire, by C. E. De Rance, F.G.S., 1877.
Geology of the Country around Prescot, by E. Hull, F.G.S., with additions by A. Strahan, F.G.S., 1882.
Geology of the neighbourhood of Chester, by A. Strahan, F.G.S., 1882.
The Geology of Liverpool, with Wirral and part of the Flintshire Coalfield, by C. B. Wedd, B. Smith, W. C. Simmonds and D. A. Wray, 1923.

Around Liverpool,' of which the following is a copy, with one or two slight variations:—

			Feet
Recent		Blown Sand, Estuarine sand and silt	100
Pleistocene	Post Glacial	Peat and Forest beds, silt and sand	25
	Glacial	Boulder Clay and sand	100
Trias	Keuper	Red Marl	1000
		Keuper sandstone	400
	Bunter	Upper Soft Sandstone	550
		Hard sandstone (pebble beds)	1000
		Lower soft sandstone	400-1270
Permian		Magnesian Limestone	10
		Marl and sandstone	65
Carboniferous		Upper Coal Measures	1200
		Middle or Productive Coal Measures	1300
		Lower Coal Measures	1880
		Millstone Grit	300

Recent Deposits.

These include the dunes and sandbanks—accumulations of wind-driven and water-drifted sands; the tidal alluvium in the form of fine sand and mud accumulated in the tidal inlets of the Mersey estuary, the shore margins, and the low lying lands which were formely overflowed by the high tides (*e.g.*, the low land around the head of Wallasey Pool; the Frodsham, Ince and Stanlow Marshes, and the adjacent lower part of the valley of the Gowy); also the alluvium in the valleys of the Weaver, the Mersey above Runcorn, and the Alt. With these we must include much of the inland peat, and the mosses (White Moss, Rainford Moss, Parr Moss, etc.), especially those lying at the higher levels. The reclaimed land (Sealand) in the upper part of the Dee estuary, where deposition of tidal mud and sand has been promoted by artificial means, also comes under this head; and the steadily-growing salt marshes or saltings which have formed in both estuaries. Borings in Sealand in search of coal showed recent marine sandy alluvium having a thickness of 75 feet.

In the recent deposits have been found marine and fresh-water shells of existing species, trunks of oak and other trees embedded in the peat, bones and horns

of the red deer and other animals, relics of man's handiwork—pottery, stone implements, metal ornaments and utensils, canoes (Martin Mere), and occasional partial or complete human skeletons.

Post-Glacial Deposits.

The post-glacial deposits occur in much the same localities as the recent deposits, viz., the lower part of the coastal plain of Lancashire and the valley of the Alt, the north shore of Wirral, the north-east shore of the Dee estuary (Caldy), in the tidal inlets and parts of the shore of the Upper Mersey estuary (Stanlow and Frodsham marshes), and up the valley of the Mersey as far as Warrington. They can be readily seen on the Lancashire coast near Crosby and Hightown, and in the neighbourhood of Meols on the Wirral coast. Being for the most part soft and incoherent, they are subject to rapid waste by tidal action; at Dove Point near Meols, Morton estimated that a strip of not less than 100 yards had been removed from the edges of the exposed beds within 30 years, while similar wasting action near Crosby and Hightown has carried away a large tract of the formerly extensive 'forest bed.' Inland the beds have been met with in trenches and excavations on Bidston Moss, in the Wallasey Pool and the Liverpool docks, in the marshes covering the low area about the mouth of the Gowy, and inland of the sandhills between Liverpool and Southport; and the continuity of the beds seen on the coast with the inland representatives beneath the covering of more recent deposits has been definitely ascertained.

The post-glacial beds have been estimated to cover an area of about 75 sq. miles in South-West Lancashire, and 7 to 8 sq. miles in North Wirral. The total thickness of the series varies from about 10 feet at Hoylake, 12 feet in Liverpool dock excavations, 20 feet and upward near the Alt mouth to over 40 feet nearer Southport. The beds appear to have been formed on an old irregular platform of boulder clay, the surface of which is now in many places much below sea level,

These deposits were the subject of long and close study by the late T. Mellard Reade, whose professional duties as a civil engineer gave him unusually favourable opportunities for obtaining full and accurate data. In an important paper by him contained in the *Proceedings* of the Liverpool Geological Society for 1871-2, the post-glacial beds are classified as follows:—

Superior Peat and Forest bed.
Formby and Leasowe marine beds (including the 'Scrobicularia Clay' of some writers).
Inferior Peat and Forest bed.

The *Peat and Forest beds* have attracted attention from early times, those at Leasowe are referred to as 'Stocks in Worold' in a poem, dated 1636, while those at Crosby were described in the *Gentleman's Magazine*, in 1796. The Inferior Forest bed, about one foot thick, containing some tree stumps and lying on the boulder clay, occurs to the west of the Leasowe embankment, though little of it now remains exposed. It has also been found in the Frodsham and Ince district, but is apparently absent as a separate bed in some of the other localities. The upper and more important Forest bed, varying in thickness from 2 ft. 6 ins. to 12 feet, is met with in most of the localities above mentioned; and though much reduced in extent by erosion during recent years there is still an area near Meols, and another at Hightown, exposed at low water, covered with black friable peat containing numerous projecting erect stumps of trees with spreading roots running down into the subjacent silt or clay, and also many prostrate tree trunks (oak, birch, pine, hazel, alder, etc.) of diameters 12 to 18 inches and upwards, and a length reaching occasionally to about 30 feet. A number of mammalian remains have been found in the peat, the large majority consisting of the horns and bones of the Red Deer (*Cervus elaphus*) and horse, with others of the ox (*Bos longifrons* and *B. primigenius*), dog, sheep and pig. These forest beds, though now extending well below sea-level represent old land-surfaces at a time when the land stood at a greater elevation.

The *Formby and Leasowe Marine Beds* consist of beds of laminated blue clay and siliceous silt, usually from about 2 to 10 feet thick, though sometimes reaching as much as 20 or more feet in thickness. They are remarkably free from stones or gravel and are known to local excavators as ' Scotch ' or ' Sea Slutch.' They gave great trouble in the excavations for the Manchester Ship Canal in the Ellesmere Port district by the readiness with which they were transformed into running mud and slutch under the water-logged peaty cover. They contain marine shells; *Scrobicularia piperata* (often *in situ*), *Cardium edule*, *Tellina balthica*, *Turritella terebra*, etc., Diatoms and Foraminifera; and from the blue clay excavated in making the Alexandra Dock the skull of a bear (*Ursus arctos*) was taken.

The post-glacial beds therefore bear testimony to several alternating changes of level, for while the two Peat and Forest beds indicate land surfaces at more than their present elevation, the intervening marine clays and silts indicate a period of subsidence and quiet deposition. The last indicated change, since the accumulation of the Upper Peat and Forest bed, is a downward movement, and some authorities (marshalled in Ashton's *Evolution of a Coast Line*) consider that there is satisfactory evidence of this subsidence having continued to the present day, and to be still in progress. Mellard Reade, on the other hand, in his evidence before the Royal Commission on Coast Erosion, and elsewhere, stated his mature conviction that there was no satisfactory evidence in this district of any vertical movement since the Roman period.

From the surface of the Upper Forest bed in the neighbourhood of Meols, a large number of antiquities in bronze and iron (brooches and other ornaments, pins, coins, implements, etc.) together with pottery, flint flakes, etc., have been collected, indicating a settlement in the district extending back to probably neolithic times. These are generally believed to have been derived from certain ' soil beds ' or old land

surfaces included near the base of the sandhills; but whether some of the older forms may have actually come from the peat bed itself is still an open question.

Glacial.

The whole of the area under consideration, except the most elevated portions (*e.g.*, the heights of Ashurst, Billinge, Frodsham, Helsby, the higher portions of the Liverpool district) is more or less covered with a mantle of boulder clay and glacial sands, lying immediately beneath the surface soil, or overlain by a variable thickness of the post-glacial and recent deposits described in previous sections. The rock-surface beneath these glacial deposits is very irregular, and in many places lies much below sea-level. The glacial beds, which tend to level up the land surface, consequently vary considerably in thickness. While the boulder clay in general may be taken as averaging from 5 to 50 feet thick, borings have disclosed very much greater thicknesses of glacial deposits. Thus a boring near Burscough Bridge (north-east of Ormskirk) before reaching the solid rock, passed in succession through 63 feet boulder clay, 90 ft. sand and gravel, 66 ft. of a lower boulder clay, followed by 21 ft. of 'drift sand,' a total of 240 feet; of which nearly 200 feet was below ordnance datum. At Widnes 163 ft. of glacial deposits were found, at Hooton 169 ft., at Ellesmere Port 90 ft., in the last named case all below O.D. In several of these cases the exceptional thickness is probably due to the presence of a pre-glacial valley, a number of such buried valleys having been disclosed by excavations or a series of borings. And as these valleys are often considerably below sea-level, they show that at the time when they were carved out by stream action, before the glacial deposits which now fill them were laid down, the land must have stood at a greater elevation above sea-level than it does at the present day.

The eastern slopes of the Flintshire range are covered with glacial deposits, which run up to a

height of 500 feet; in Wirral they occur to a height of about 300 feet on the side of Heswall Hill; in S.W. Lancashire they extend to near the summit of Ashurst Hill and Billinge Hill, which heights, judging from the presence of these glacial beds, and also the displacement of the beds (viz., the 'terminal curvature' referred to later) appear to have been completely overridden by the ice sheet.

The *Boulder Clay* forms low cliffs along the eastern side of the Dee estuary rising to a height of 50 feet or more at Thurstaston and Dawpool, where on the foreshore lie numerous large and small boulders derived from the wasting cliffs. Similar cliffs to those at Dawpool occur on the western shore of the Mersey estuary from Seacombe to near New Brighton, now in large part masked by the marine promenade; while clay cliffs up to 30 feet in height occur also on the other side of that estuary from Dingle Point to Hale Head. Fine sections of the clay have been exposed from time to time in excavations for docks, sewers, etc.; and in Liverpool, Birkenhead, Seacombe, and many other places extensive excavations and clearings of clay have occurred for brick-making purposes, for which the boulder clay has been extensively used.

The boulder clay of the district around Liverpool is a stiff brown or reddish brown clay, which when mechanically analysed is found to contain, intimately mixed with finer material, a large proportion of sand and fine gravel, up to from 30 to 40 per cent. Distinct layers and pockets of sand and fine gravel also occur at certain horizons in the clay and these are sometimes developed to such an extent (10 feet or more in thickness) as to lead the older writers to distinguish an Upper and Lower Boulder Clay, with an intermediate division termed 'Middle Sands and Gravel.' As the presence of these beds of sand, however, is very inconstant and where considerably developed they are found, in some cases at least, to thin out and disappear when traced for some distance, this threefold division of the principal glacial deposits is not now generally followed.

At the same time it is recognised that the lower part of the clay is, as a rule, more sandy and contains a larger proportion of rolled stones than the upper portion. The clay in most places contains a considerable number of shell fragments, and Morton gives a list of over 50 species of shells recognised in the local glacial deposits (*Astarte borealis*, *Fusus antiqua*, *Saxicava rugosa*, *Cyprina islandica*, etc.), nearly all of which are still living in the neighbouring seas. Mellard Reade showed in a series of papers that the boulder clay from many points is very rich in foraminifera, among those most frequently occurring being *Nonionina depressula* (very common and abundant), *Polystomella striato-punctata*, *Rotalia Beccarii*, *Lagena laevigata*, etc.

The clay contains a number of large and small subangular and partly rounded stones, a large proportion of which (more than half in some cases) have rubbed and striated surfaces. Some few of these are of Triassic sandstone, or Keuper Marl with salt pseudomorphs and fragments of gypsum, similar to the rocks of the district; but the great majority are '*erratics*,' and are believed to have come in great part from the Lake District or South Scotland. Among those that have been definitely identified are granite from Criffel, dolerites and tuffs from Ayrshire, porphyrites from the Cheviots, Eskdale granite, Buttermere granophyre, volcanic tuffs and agglomerates of the Borrowdale series, Lake District andesites; eurite from Ailsa Craig; one specimen of olivine-diorite in contact with chalk, probably from the north of Ireland, together with occasional pieces of hard chalk and flints probably derived from the same district; blocks of fossiliferous Liassic limestone, possibly from the Cumberland outlier. A large boulder of Criffel granite measuring 7 ft. by 6 ft. and weighing probably 10 tons was found near Burscough, and others of about the same size at Dawpool. One of the most interesting boulders met with consists of a block of gypsum estimated to weigh 18 tons, found in a clay pit at Great Crosby, and now

placed (at the suggestion and by the efforts of Mellard Reade) in an enclosed space in that village with the same orientation as it had when lying in the boulder clay. (A full description of this boulder was communicated by Mr. Reade to the Liverpool Geological Society and appears in the *Proceedings* for session 1898-9). Quite recently a large boulder of Carboniferous Limestone estimated to weigh over eight tons has been found in the clay during the excavations for the new Gladstone dock at Liverpool. In many cases throughout the district the larger erratics have been placed as guard stones by the sides of the entrances to farm yards, etc.; while the smaller erratics from the brickyards, or those collected from the surface of the cultivated land, have been used as cobble stones for pavement of roads, causeways, yards, etc., or broken for macadam.

Where the boulder clay lies upon Triassic sandstone beds it is frequently found that under the clay is a layer of broken rock and rubble passing into red or yellow sand, evidently derived from the disintegration of the subjacent rock. Sometimes this sand is stratified as by water action. This material is described by Morton as 'Lower Drift Sand and Gravel.' Where this sand and rubble is not present, the rock surface, when freshly uncovered is found in many places to be planed and striated; the direction of the *striae* lying in general between N. and N.W. to S. and S.E. The very general agreement in the direction of the striae over nearly the whole district is consistent with the opinion, now widely accepted, of their production by an ice sheet moving in an approximately south-easterly direction from the Irish Sea. Such striations in the Liverpool district have been recorded up to 180 ft. at Bidston Hill (still visible), 190 ft. at Mossley Hill (Liverpool), and 240 ft. at Thatto Heath, near St. Helens; and up to more than 800 feet on the Flintshire side. Several examples of *terminal curvature* of the edges of the strata by the passage of the ice have been described from the district; one, recently described by Mr. C. B.

Travis, showing the turned back edges of thin fissile beds of Lower Carboniferous Sandstone, was exposed on the slopes of Billinge Hill at an elevation of about 440 ft.

There is a considerable development of *Glacial sands and gravels* in the Cheshire part of our area, especially in central and eastern Wirral (*e.g.*, Little Sutton, Backford, Mickle Trafford), in the form of extensive mound-like accumulations of red or yellow sand, containing strings of gravel and shell-fragments, and often showing signs of current-bedding. These masses, which may reach a thickness of over 60 feet, are correlated by Morton with the Middle Sands and gravels. The sands have been extensively worked at Backford and other places for building purposes.

A very considerable area in S.W. Lancashire and some parts of Wirral are covered with beds of loose sand and gravel, which are sometimes described as the uppermost member of the glacial series under the name of 'Upper Drift Sand' (Morton) or "Washed Drift Sand" (Reade) and which appear to represent the same beds formerly described by De Rance in the district between Liverpool and Southport as '*Shirdley Hill sand*.' The latter considered them to represent a line of ancient sand dunes, approximately on the 25 ft. contour line, at the inland edge of the peat moss coastal plain. The thickness varies considerably, and in some places reaches 30 feet and more. The sand also occurs in isolated patches in the neighbourhood of Liverpool, lying in hollows in the surface of the boulder clay. Others regard these sands, as they often occur, as derived by the washing and re-assorting of the upper part of the boulder clay. The Shirdley Hill sand is extensively used, after being washed, for glass making in the St. Helens district.

Triassic.

The newest beds in the geological series, which occur beneath the general mantle of recent and glacial deposits in this area, are the sandstones

and marls belonging to the Triassic period, which constitute the whole of the solid geology of the Cheshire section and that of the less elevated western portion of Lancashire. The sandstones furnish valuable building-stones and have been largely quarried for that purpose at Liverpool (Everton, St. James' Cemetery), Bootle, Woolton, Rainhill, Wallasey, Tranmere, Storeton, Heswall, and Runcorn. The same beds, and especially the Middle Bunter, at deeper levels constitute an important reservoir of drinking water, which until comparatively recent times was drawn upon by means of deep wells as the sole source of supply for Liverpool, Birkenhead, Wallasey, and the surounding areas, and still furnishes the only supply for a large portion of Wirral and many districts in Lancashire. The quarries, the boring and sinkings for wells, and the extensive rock-cuttings by which the principal railways pass through the high ground on which Liverpool stands to reach their termini, have afforded numerous opportunities for the study of the Triassic beds.

**Faults.*—' The Triassic strata are intersected by numerous faults running in a north and south direction in South-West Lancashire, Cheshire, and to a large extent in the coal-measures. In the Carboniferous Limestone of Flintshire and Denbighshire, this prevailing line of the faulting is remarkable. Nearly all the faults about Liverpool run either due north and south, or about 10^0 east or west of north. There are very few east and west faults and these merely run between the main faults. The north and south faults are so numerous, and their exact direction and continuity so uncertain, that no satisfactory geological map of the area under the city is possible. At Storeton 22 faults are shown—and 17 of these run nearly north and south, and only 5 run east and west and are small faults of little importance.'

* This paragraph and succeeding paragraphs marked with an asterisk, and placed between quotation marks, except portions within square brackets [ ], are taken from the article by G. H. Morton, in the Handbook prepared for the meeting of the Association in Liverpool, 1896.

A.—Keuper.

The two great divisions of the Trias, viz.:—the Keuper and the Bunter are both well-represented in the area, and the junction of the two formations is visible in several places.

The Keuper series may be divided in descending order (1) Red Marl; (2) Waterstones; (3) Building-stone; (4) Basement beds.

**Red Marl.*—'This is the highest sub-division of the Keuper formation and consists of red and grey marls and shales with interstratified beds of sandstone of a dull red colour. The base may be seen in St. James' Cemetery (Liverpool) resting on the underlying yellow beds of the Keuper Sandstone. Although only about 0 feet are exposed it is known to be 100 feet thick, as there are higher beds to the east. Some of the flaggy beds are ripple-marked and contain pseudo-morphic crystals of chloride of sodium. [These beds in Liverpool are now classed by the survey as belonging to the Waterstones.] The Red Marl is well-exposed in many places in Wirral, there being [formerly] a small exposure of it on the east of the Storeton Quarries and another on Oxton Hill [Birkenhead]. It extends over a considerable area in the centre of Wirral, from near Leasowe Castle on the north to Thurstaston on the south, and from Woodchurch to Frankby two miles from east to west. The clearest exposures are about Woodchurch, Upton, and Greasby. . . . A boring for water was made at Ford, in the valley west of Bidston Hill, and the Red Marl was found to be 455 feet thick; and a boring in search of brine or salt was made about a mile north of Altcar and it was there found to be 971 feet in thickness.'

The marl occurs on the Lancashire side under the glacial and post-glacial deposits from Crosby to Southport. From the Frodsham and Helsby hills it extends eastward into the Cheshire plain. A chemical analysis of the Red Marl from Wirral by Messrs. Greenwood and Travis proved it to be highly calcareous; a sample from a brickfield at Seacombe showed 8.34

per cent. of carbonate of lime, and another specimen from the Ford boring, 44 per cent.

Waterstones. The maps of the Geological Survey for the Cheshire area, and some of the later maps for South-West Lancashire show the Waterstones as a distinct division of the Keuper. In the second edition of the memoir on the *Geology of the Country about Prescot*, the term is said to have been originally applied to a series of sandstones interbedded with shales, as descriptive of the abundant supply of water they afford in consequence of the alternation of porous and impervious beds. These thin flaggy beds of red and grey argilaceous marls and sandstones were included by Morton as the lowest part of the Red Marl and it is difficult to draw any clear line of division between the two. Probably a large part of the beds in north Wirral (Greasby, Irby, etc.), perhaps also in West Lancashire, might be classed as Waterstones,—they are mineralogically and chemically not true Marls.

**Building-Stone and Basement beds.*—'This subdivision rests on the eroded surface of the Bunter, and the lowest beds consist of coarse sandstone with interstratified bands of marl. At the base there is a conglomerate containing quartz and other pebbles and lumps of rolled marl. Higher up the sandstone is generally softer, though there are occasional bands of coarse grit. The miscroscopic character varies considerably, from rounded grains to others rendered angular by the deposition of secondary quartz. Little can be seen of the Keuper Sandstone under the city, for it has been almost entirely built over, but in Wirral, between Storeton, Oxton, Bidston Hill, and Wallasey there is almost a continuous ridge, and numerous quarries where the strata may be examined. It also extends considerably to the North of Liverpool and over a large area in Cheshire.

'The extensive quarries at Storeton (in Cheshire), four miles from Liverpool, expose 172 feet of sandstone and marl, traversed by so many faults that they are of unusual and instructive interest. The lowest beds

Slab of Keuper Sandstone, about 5 feet 9 inches long and 8 inches thick, from the Storeton quarries, showing impressions of footprints (*Cheirotherium* and *Rhyncosaurus*), plant stems (*Equisitites*), suncracks, ripple marks, &c.; in the left-hand figure (i.e. upper surface of bed) in intaglio, in the right-hand figure (lower surface) in relief. (From the Liverpool Free Public Museum).

are formed of coarse grit and contain small pebbles and fragments of marl, while the higher beds of white sandstone have been for many years the principal building stone used on both sides of the Mersey. The "footprint bed" is 124 feet above the base of the Keuper, and is usually from 3 to 4 feet in thickness. It contains a few thin seams of clay, on which the footprints of the *Cheirotherium* [and *Rhyncosaurus*] were made and preserved as casts on the underside of the overlying sandstone. The remains of a plant, *Equisetites Keuperina*; have been found, and ripple marked surfaces, and the casts of raindrops are of frequent occurrence. The thickness of the Keuper Sandstone under Liverpool is about 400 feet, the result obtained by measuring the beds in the railway cutting,' [between Lime Street and Edge Hill. The Keuper sandstone constitutes a belt running north and south through the centre of the city, being faulted down against the Upper and Middle Bunter (which latter forms the highest portion of the ridge), the amount of throw being estimated by Morton to reach 1,000 feet in the northern part].

The very large old quarry on the east side of the site of the new Liverpool Cathedral, which was afterwards converted into St. James' Cemetery, supplied a considerable quantity of Keuper building-stone for the buildings of Liverpool. Other important quarries in the Keuper occur at Heswall and at Runcorn (near Weston Point). While the greater part of the building-stone from Storeton is light grey or cream-coloured, and at St. James' Cemetery of a yellowish colour, that from Heswall and Runcorn is red or brown.

The Keuper sandstone at Frodsham and Runcorn comprises a series of soft beds, mostly of a deep red colour, which have been described under the name of 'Frodsham beds.' The hard basement beds of the Keuper form the crest of the hills at Bidston, West Kirby (Grange), Frodsham and Helsby, dipping gently towards the east, and exposing the underlying Upper Bunter in the steep escarpments on the western faces.

Footprints have been found at Storeton (first by Cunningham in 1838), Runcorn, Oxton, and Great Crosby, and have been fully described and classified by the late H. C. Beasley. Some fine specimens may be seen in the public museums at Liverpool (including the Beasley collection), Birkenhead, and Bootle (where the slabs obtained and described in the earlier period are exhibited); while there are fine slabs and type specimens also in the Geological Department of the University. The late Mr. F. T. Maidwell described a number of footprints from the Keuper beds of Runcorn Hill, where they occur in the quarries at the base of the 'Middle Fey,' just over the 'Bottom Rock,' about 60 to 80 feet above the base of the formation, the footprint bed with a thin marl parting varying from 2 inches to 2 feet in thickness.

B.—Bunter.

The Bunter series, consisting entirely of sandstone rocks, is divided into three formations, (1) the Upper Soft or Mottled Sandstone; (2) the Middle Bunter Sandstone, called Pebble Beds by the Survey, but by Morton described as the Upper and Lower Hard Sandstone; and (3) the Lower Soft or Mottled Sandstone.

The *junction* of the Lower Keuper with the underlying Bunter may be seen in several localities, e.g., the road cutting through Bidston Hill; the section exposed adjacent to the Poulton Railway Station, Wallasey; in a road cutting on the hill behind West Kirby; at Helsby Hill; and at Scarth Hill, near Ormskirk. An unconformity between the two series has often been described, but is not well marked.

**Upper Soft (or Mottled) Sandstone.*—'This is the highest sub-division of the Bunter formation and is well-exposed in the railway cuttings on the north and south of the city. It forms picturesque cliffs at Dingle Point on the south shore, and at the Red and Yellow Noses just beyond New Brighton, where the yellow sandstone reposes on the red sandstone. None of the sandstone of this sub-division is fit for use as a building

stone, and it is usually so soft and incoherent as only to be used as sand. The sandstone is composed of small grains of quartz of a seed-like character, but without the large rounded grains so common in the Lower Soft Sandstone. The highest beds are often of a bright yellow colour with inter-stratified white bands, as about the north of the city and from New Brighton to Bidston, Oxton and Storeton. The usual colour . . . . however, is a bright red with white streaks, the yellow beds at the top being exceptional and not exceeding 120 feet in thickness . . . The thickness of 550 feet was obtained from the boring for water at Flaybrick Hill and other places.'

These beds constitute the surface rock over a considerable area in central Wirral and in the lower valley areas to the east and north-east of Liverpool. In the neighbourhood of Ormskirk they are well-exposed by the side of the railway, where, as also at Runcorn, they are largely worked for sand for moulding, etc. The beds are very frequently current bedded; and in some places (*e.g.* road-cuttings at Thurstaston Hill and in Wallasey Village) sections show very much curved and contorted bedding-planes. Some thin, hard beds of sandstone occurring among the characteristic softer beds of the series are specially marked on the survey map in the neighbourhood of Caldy and Thurstaston, on the west side of the Wirral peninsula.

**Middle Bunter Sandstone.*—[This was described by Morton in his later work as consisting of two subdivisions, as follows]: (*a*) '*Upper Hard Sandstone.*—Upper Pebble-beds with few or no pebbles. This subdivision occurs and may be examined in numerous excavations on the east of the city, particularly in Edge Hill, Everton and Bootle. The sandstone is of a brown or dull red colour, with grey streaks from a few inches to a foot in thickness, but without any pebbles, except perhaps in the lowest beds, as about Kirkdale and Walton, which gradually pass into the underlying sub-division. It is well-exposed in the railway cutting at Edge Hill, where it presents a solid bed of hard

sandstone, without any seams of shale dividing it into separate beds.

*' Between Egremont and New Brighton the Upper Hard Sandstone is well exposed, particularly around the Fort and Lighthouse, and the absence of pebbles is remarkable. None were found during the construction of the Mersey Tunnel [which is cut through this rock], and it is principally on account of the absence of pebbles that the separation of the original ' Pebble-beds ' was adopted. About the east of Liverpool the sandstone of this sub-division is extensively used as a building-stone. Many of the churches and other edifices are formed of it, besides most of the sills and lintels of the doors and windows throughout the city.'

*(*b*) ' *Lower Hard Sandstone with Pebbles.*—Lower Pebble beds with numerous pebbles. This sub-division is well-exposed along the [Liverpool and Manchester] railway through Olive Mount, near Wavertree, and in quarries about the latter place, Woolton, Speke, Rainhill, and many other localities east of Liverpool. It also occurs at Bromborough, Eastham, Ince, Neston, Burton Point and Hilbre Island, in Wirral. . . . It is a hard brown sandstone, separated into beds from 6 to 10 feet in thickness by bands of red and grey shale, and contains numerous pebbles of quartzite, vein quartz, grit and black chert. These are usually scattered through the sandstone, but sometimes are so numerous as to be indented where pressed together. Some of the beds do not contain pebbles, and are extensively used as a building stone, while those with pebbles are useful for rougher purposes. Besides pebbles, nodules of red clay are of common occurrence . . .

*' The finest exposure of the Lower Hard Sandstone is that [in the deep railway cutting] at Olive Mount, where the beds dip to the east, and the thickness is about 400 feet, but neither the highest nor the lowest beds are visible. Pebbles occur there in nearly every bed, and the uniformity in average size and distribution is very remarkable, for in other localities thick beds with numerous pebbles alternate with others in which

very few occur. In a few localities the beds have a brecciated character, particularly at Hilbre Island and Hilbre Point, near West Kirby. The thickness of the Lower Hard Sandstone, forming the inferior part of the "Pebble-beds" of the Geological Survey was proved to be 600 feet in the boring for water at Bootle. In this boring, in 1878, the first pebbles were found at the depth of 415 feet, and the last at 1,026 feet, proving the thickness to be 611 feet, or 600 feet after allowing for the slight dip of the beds.'

The hard beds of the Middle Bunter form the high ground in the eastern part of Liverpool, and the ridges at Wavertree and Rainhill further east, as well as the elevations at Wallasey and Tranmere on the other side of the Mersey. The brown sandstone which is being used in the construction of the new Liverpool Cathedral is obtained from selected beds in the Middle Bunter sandstone quarries at Woolton, near Liverpool. The breccia bed seen at the base of the cliffs on the west side of Hilbre Island, appears to be a very local deposit containing fragments of sandstone, grit, carboniferous limestone, etc.

*'*Lower Soft* (*or Mottled*) *Sandstone*.—This subdivision occurs over a considerable area between Old Swan and Huyton, Prescot, St. Helens, Rainford [on the Lancashire side]; and Burton Point, near Neston [on the Wirral shore of the Dee] where it crops out from beneath the Lower Hard Sandstone. It consists of soft beds of bright red sandstone, though sometimes yellow and orange as near Huyton. The sandstone is composed of rounded seed-like grains, usually larger than 1/100 of an inch in diameter, but beds of larger grains, 1/35 to 1/25 of an inch, in a matrix of smaller ones, are of frequent occurrence about Huyton.'

The thickness of this division in Cheshire has been proved by borings to be much greater than was formerly believed. A boring to the west of Ince, near Ellesmere Port, showed a thickness of 920 feet, while in the deep Heswall bore-hole, near the Dee shore of Wirral, 1,272 feet of these beds were pierced. (The

Heswall boring in 1908 was carried to a total depth of 3,362 feet; 2,314 feet of Bunter Sandstone being passed through before the Coal Measures, consisting of shales and sandstones with thin seams of coal, were reached.)

The Constitution of the Local Triassic Rocks.

The microscopic structure of the local sandstones has been studied and described by Morton, Reade and Lomas, and both microscopic character and chemical composition by Dickson and Holland, and (for Wirral) by Greenwood and Travis: the results of their investigations being given in papers published in the *Proceedings* of the Liverpool Geological Society.

The sandstones consist of rounded, sub-angular and angular grains of quartz, the rounded and worn character being much more marked and persistent in the Bunter sandstones than in those of the Keuper, as many as 81 per cent. of rounded grains having been found in a specimen of the Lower Bunter. The size of the grains varies from 1/500 to 1/25 of an inch, the larger grains being more abundant and characteristic of the Upper and still more so of the Lower Soft Sandstone. The Keuper Marl contains a large proportion of very fine quartz dust and minute splintery fragments, while the nodules and bands of "marl" intercalated with the Keuper sandstone consist almost entirely of such fine siliceous matter. In the Keuper sandstones generally there is a secondary deposit of silica upon and between the original grains of the rock, often presenting distinct crystalline faces and in some cases perfect doubly terminated prismatic crystals. The Bunter sandstones contain less of this secondary silica, possibly because the large impregnation of iron oxide and other impurities interfered with the deposition. Grains and dust of felspar are present in nearly all the sandstones and form a conspicuous element in the Pebble beds and the Middle and Lower Keuper, sometimes to the extent of 18 per cent. The felspar is as a rule kaolinized, and while orthoclase seems to be the most prevalent form, some microline and much decom-

posed triclinic varieties occur. Mica is frequently present.

Greenwood and Travis describe the cementing material as (*a*) Silica in the form of quartz flour and secondary growths, the latter being in their opinion of far less importance as a cement than is usually supposed; (*b*) Iron in the form of limonite, and, less frequently, haematite, the iron content being in their opinion an original constituent of the beds; and (*c*) carbonates in the form of calcite and dolomite, which they also regard as original constituents, being very constant in the deeper beds, though usually absent or surface. Among the heavy minerals which have been separated and identified are magnetite (almost invariably present), zircon (the most abundant), rutile, anatase, tourmaline (brown and blue varieties), ilmenite, leucoxene, apatite (rare), barytes, etc. The absence of garnets is worthy of note.

Miss Stella Harris who has recently investigated the constitution of the Triassic rocks of S.W. Lancashire finds among the heavy minerals, anatase, rutile, zircon, ilmenite and tourmaline as most common and nearly always present, together with garnet (rare), magnetite, biotite, brookite, epidote (very rare), and monazite (rare, in well rounded grains), etc. The lighter minerals consist of quartz, with orthoclase as the most abundant felspar, microline fairly abundant and some plagioclase.

Pebbles of quartzite, lydian stone, chert, etc., occur in the basement beds of the Keuper at Storeton; and among the pebbles of the Middle Bunter (Pebble Beds), T. A. Jones has described quartzites and grits (forming the most numerous and largest specimens), granites and granophyres, mica schists, felstones, tourmaliniferous schists, etc. Fossiliferous pebbles are very rarely met with, consisting of cherty material with sponge spicules or crinoidal remains.

The general character and disposition of the beds, as well as a study of the characters and constitution of their component particles, have led to the very gener-

ally accepted conclusion that they were, in large part, originally formed under arid or desert conditions of climate. The abundance of well rounded (and therefore probably wind-borne) sand grains, the occurrence of beds of salt and pseudomorphs after salt crystals, the sporadic thin beds of marl intercalated in the sandstones and occasionally bearing impressions of footprints, ripple marks, suncracks, etc., are among the facts which have led to this conclusion.

Permian.

The nearest undoubted occurrence of beds of Permian age in our area is at Bispham, about six miles north-east of Ormskirk, where they are exposed in a stream-cut dell known as Skillaw Clough. They were first described by E. Hull, in 1866. The section shows a bed of hard Magnesian limestone, 5 to 6 feet thick, of a grey colour weathering to yellow. An analysis of the limestone by Mr. E. Dickson showed that it contained 57 per cent. carbonate of lime, and 24 per cent. carbonate of magnesia. The same observer found in the limestone a specimen of *Schizodus Schlotheimi*. Underlying the limestone are beds of purple shales and marls with thin bands of limestones containing *Gervillia antiqua* and other fossils, the series having a total thickness of 30 feet. Underneath these shales are beds of soft red sandstone, in which no fossils have been found, which have a thickness of 35 feet and rest unconformably on Millstone Grit.

Another exposure occurs about one mile to the north-east of Skillaw Clough, in Bentley Brook, which has recently been examined and described by Miss M. Workman. Proceeding upstream the sequence in descending order is as follows:—

Trias.—Bright red and yellow sandstones varying in hardness, but usually soft.

Permain—

Purple red fine sandstone, sometimes marly.

Magnesian limestone—a thin band.

Compact dark red and variegated sandstones with shales interbedded.

The actual junction of the Trias and Permian is in the bed of the stream, but the outcrops can be seen within a yard of each other.

The Permian sandstones from these localities vary in colour (from purple-red to brownish), in texture and in hardness, sometimes bands of very large quartz grains occur. The heavy minerals found were.—Pyrite (especially in the lower compact sandstone), Magnetite, Garnet, Zircon, Rutile, Anatase, Xenstime, Tourmaline, Ilmenite, Haematite, Hypersthene, Muscovite, Epidote, Chlorite and Monazite, beside Calcite and Barytes as cementing materials and also alteration products. Monazite and Hypersthene were very rare and Tourmaline included the rarer pink and blue varieties.

The mineral assemblage is very similar to that found in the neighbouring Millstone Grit which in turn resembles that of the Millstone Grit of Leeds, described by Prof. Gilligan; particularly in the undulose extinction of the quartz and mica, the freshness of the felspar, the cleavage of the garnets and occurrence of monazite. Everything points to the Permian having been derived from the Millstone Grit under arid, but not hot, desert conditions, as the grains show signs of transport by water as well as by wind.

Former exposures of Permian strata have been described by Mr. E. W. Binney and others from the neighbourhood of St. Helens; and beds of soft sandstones and marls, supposed by some to be of Permian age, have been met with below the Middle Bunter in borings at Prescot, Halewood, and elsewhere in the neighbourhood. It appears, however, to be difficult, if not impossible, in the absence of fossils, to determine whether these beds represent a special form of the Lower Bunter Sandstone, as some authorities claim, or are properly to be referred to the Permian. In some of these doubtful beds have been found a considerable number of 'sulphur balls,' or nodules consisting of sand-grains (often beautifully rounded and of the 'millet seed' type) cemented together by iron pyrites or marcasite; and Mr. T. A. Jones has described some-

what similar concretions found in the beds in Knowsley Park, which are mapped as Lower Soft Sandstone.

Carboniferous.

*(*a*) *North Flintshire.*

'The Carboniferous Limestone, Cefn-y-Fedw Sandstone and Coal Measures of the north of Flintshire, occur within 20 miles to the south-west of Liverpool, and are all conspicuously exposed. . . . Near Prestatyn the Carboniferous Limestone is exposed in a fine section, about four miles in length, with each of its sub-divisions cropping out in succession and presenting unusual facilities for examination . . . [The succession in North Flintshire is as follows:—]

		Feet
Coal Measures	Middle or Productive Coal Measures	700
	Lower Coal Measures	300
Cefn-y-Fedw Sandstone	Gwespyr Shale	150
	Gwespyr Sandstone	120
	Holywell Shale	100
	Cherty Sandstone	250
Carboniferous Limestone	Upper Black Limestone	200
	Upper Grey Limestone	500
	Middle White Limestone	600
	Lower Brown Limestone	400
	Red Basement Beds	3
		3323

*'[The Cefn-y-Fedw Sandstone] probably represents the Yoredale series, the Millstone Grit, and possibly includes some strata belonging to the Lower Coal Measures; and a new name was given to the strata occupying this position in North Wales because of a difference of opinion that prevailed as to which of those formations it represented.'

The Cefn-y-Fedw Sandstone and Carboniferous Limestone of North Wales were very fully described by G. H. Morton in a series of papers published in the *Proceedings* of the Liverpool Geological Society. A recent paper by Mr. T. A. Jones in the *Proceedings* of that Society for 1920-21 contains the results of a careful study of the microscopical characters of the Carboni-

ferous Limestone of North Wales. These beds, according to Wheelton Hind and Stobbs, appear to correspond to the zones of Dibunophyllum (D_1 and D_2), and possibly Seminula (S_2), established for the Bristol area; and it is considered by some authorities that the Upper Black Limestone, of Morton, is really of later age than the Carboniferous Limestone period and contains a typical Pendleside fauna. 'The Carboniferous Limestone of North Wales,' according to T. A. Jones, 'is made up principally of the remains of crinoids, corals, polyzoa, brachiopod and other shells, together with foraminifera, cemented by a varying amount of clear re-crystallised calcite. . . . Detrital quartz grains are seldom entirely absent, and not infrequently are sufficiently abundant in the lower and upper beds to give an arenaceous character to the limestone. Small, perfectly formed quartz crystals are also common up to 1 mm. long, and the insoluble residues of many of the beds often consist principally of minute bipyramidal crystals.' Associated with the limestone are beds of massive grey and black chert, and there are also thin bands of chert incorporated with the limestone. The latter bands are mainly of organic origin and contain spicules of sponges, foraminifera, etc. These chert beds are well seen above Holywell and near Prestatyn.

(*b*) *South-West Lancashire and Wirral.*

* 'The Carboniferous is represented by the Millstone Grit and the Coal Measures, and both occur a few miles to the east of Liverpool [with an average total thickness of 4,680 feet].

* '*Upper Coal Measures.*—The finest exposure is in the cutting of the Liverpool and Manchester Railway between Rainhill and Marshall's Cross Stations, where the strata consist of red and purple shale, clay and sandstone. The red colour is supposed to have been derived from the infiltration of ferruginous water from the overlying Permian and Trias, and descends 200 or 300 feet from the surface, but at a greater depth the shales are black and the sandstone of the usual grey

colour . . . At Collins Green and Bold, near Newton, coal pits have been sunk through the base of the Trias and the whole of the Upper Coal Measures, into the Middle Coal Measures beneath and prove the thickness to be 1,200 feet. Near Whiston there is a small area of the strata of this sub-division, including a bed of reddish compact limestone about 4 feet thick containing

Spirorbis pusillus . . . .

* ' In 1870 the excavations along the Huyton and St. Helens Railway exposed a section of great interest, for the Upper Coal Measures were seen in several places faulted against the Lower Soft Sandstone of the Bunter formation.'

* ' *Middle or Productive Coal Measures.*'—This sub-division is the most important, for it contains all the thick and valuable beds of coal. The nearest exposures are about Prescot and St. Helens, where many collieries are worked and the interstratified beds of shale and sandstone may be examined. Some of the Middle Coal Measures [were formerly to] be seen in a large quarry on the south-west of St. Helens where Messrs. Doulton and Co. [obtained] shale for making bricks and tiles, and where the strata are about 126 feet in thickness. The highest beds consist of thin shale and sandstone containing 4 or 5 very thin seams of coal and there is a much greater thickness of shale below.

* ' During the construction of the Huyton and St. Helens Railway in 1870 a fine exposure was made of the Ravenhead Main Coal at Thatto Heath. About 8 feet below the coal there was a remarkable line of the trunks of trees in the position in which they grew, and usually 4 or 5 feet from the roots upwards. In the black shale below the trees many fossil plants were collected by the late Rev. H. H. Higgins and are preserved in the [Liverpool] Free Public Museum, and known as the Ravenhead Collection.'

On the Wirral shore of the estuary of the Dee in the neighbourhood of Neston the Middle Coal Measures occur, overlaid by the Boulder Clay. The Coal seams

in these beds have been worked for many years; they vary in thickness from 2 ft. to 7 ft. 6 in., and may be roughly correlated with those met with on the other side of the Dee in Flintshire.

* ' *Lower Coal Measures* ' or "Gannister beds" overlie the Millstone Grit. . . . They were formerly worked for flags at Huyton Quarry, east of Liverpool. . . Coal was obtained from one of the "Mountain Mines" in the sub-division in Knowsley Park, about 100 years ago. There is a considerable area, several square miles, of the Lower Coal Measures between Prescot and Parbold, and a fine section in the railway cutting at Pimbo Lane Station, originally described by Mr. E. W. Binney. . . . The strata consist of black shales, micaceous flaggy sandstones, and two or three thin beds of coal.

* ' South of Pimbo Lane is Billinge Hill, and there are quarries in the sandstone near the Beacon, which is on the highest ground, 593 feet above ordnance datum. . . . The quarries on the hill exhibit large concretions of sandstone of a remarkable character from 1 to 12 feet, but usually 2 to 4 feet in diameter; and a boulder of granite 18 inches in diameter was found in the rock a few years ago. In the lowest bed numerous stems of *Calamites*, *Bothrodendron*, *Lepidodendron* and *Ulodendron* were found.

*"The *Millstone Grit* forms the lowest sub-division, and the only exposure of it near Liverpool is in Knowsley Park, where it occurs and may be examined in quarries to the east of the Hall. It is well exposed at Grimshaw and Haughton's Delf, two miles from Upholland, or 12 miles from Liverpool . . . Large quantities of fine and coarse grained white grit are obtained and are principally used for making square setts and curbstones for roads, and the waste is used as macadam.

* ' The most important exposure . . . is at Parbold and Harrock Hills, 16 miles N.N.E. from Liverpool. The grit forms a semi-circular range of hills, with the Lower Coal Measures overlying it. There are several large quarries, and the rock consists of thick bedded, coarse, yellow and red sandstone; some being a typical

grit containing so much felspar and mica as to resemble granite. The thickness of the grit at Parbold is 90 feet and it is underlaid by shales, flagstones and a thin bed of coal . . . The thickness of the Millstone grit, including the shales below the sandstone is about 300 feet, but that of the whole is unknown, as only the upper portion of the sub-division is exposed.'

[Note.—*The writer desires to acknowledge his indebtedness to Professor P. G. H. Boswell for much valuable advice and criticism.*]

BOTANY.

VEGETATION OF THE LIVERPOOL DISTRICT.

E. H. Rideout, B.Sc., A.I.C.

For botanical purposes the Liverpool district has usually been defined as an area of some 15 miles round the Port. No attempt is made in these pages to provide complete lists of any natural division of plants, but the following notes aim at giving a concise description of the plant formations occurring, with some account of the special factors influencing their distribution. Owing to the gently sloping nature of the land from the sea level to a maximum altitude of only 550 feet rainfall is fairly constant throughout, but South-west Lancashire and Cheshire are somewhat drier than the remainder of the Western coast of the country by reason of the sheltering effect of the hills of Flint. The coastal area is exposed to westerly gales which exert a considerable effect on the growth of shrubs and trees. With two exceptions the geological foundations of the area consist of Triassic sandstones forming a basis upon which later glacial clays and sands and the more recent deposits of blown sand and alluvium rest.

Plant formations on sand and sandstones are to a certain extent similar. In this district the recent sands occur only in the coastal region and give rise to typical Dune Formations. Normal sands and sandy loams directly derived from the Trias are occupied by dry grassland which, however, tends to revert to heath by the accumulation of organic matter giving rise to peat.

On the permeable subsoil of Triassic rock the peat remains thin, but on the glacial sands resting in the hollows of the Lancashire plain, upon impermeable boulder clays, there is developed the deep peat of the 'Mosses.'

The coastal plain is defined by a line of low cliffs stretching from Grange Hill through Upton and Bidston in Cheshire, and Aintree, Kirkby and Aughton to Burscough in Lancashire. Following the deposition of glacial drift upon the plain, there arose to seaward a line of sand dunes, which, holding up the drainage of the low-lying lands, caused them to be occupied by marsh vegetation. A portion of the Cheshire coastal plain was until recent years occupied by salt marsh.

Plant Formation of Clays and Loams.

The soils covered with glacial drift which occupy so large an area in South Lancashire and Cheshire may be roughly divided into two classes, clays and sands. The term clay, or clayey loam, is in this area somewhat vague, comprising a number of soils which vary from an open loam, containing little true clay, to the heaviest boulder clays found along the river valleys. In general it is assumed that in this climate these clay-lands would naturally bear a woodland formation; but being for the most part employed either as arable land on the lighter soils or as permanent pastures on the heavier types, practically no original natural woodland now remains.

Relics of a primeval forest, probably destroyed in Neolithic times by intercepted drainage, are exposed on the Cheshire coast at Meols. Certain records which have been recently examined confirm the belief that a great number of the fields now under permanent grass have been in this condition for two or three centuries, thus a study of their vegetation would be expected to give a tolerable idea of the natural grassland of the district.

The dominant tree is *Quercus Robur*, associated with:—

Acer Pseudoplatanus
Corylus Avellana.
Fagus sylvatica.
Ulmus montana.
U. campestris.
Salix sp.

Little detailed work has been done from the ecological standpoint on the ground flora of the numerous plantions, but a superficial examination reveals many features in common with the communities on similar soils in the Midland district of England. In a few instances a seasonal dominance of various herbs can be seen, including associations of *Scilla nutans*, *Digitalis purpurea*, *Primula vulgaris*, *Ranunculus ficaria*, which are notable features of some of the smaller woods and plantations.

A certain amount of scrub results from the clearing of woodland, but over 50 per cent. of the area is occupied by permanent grassland. This grassland is of a neutral or slightly acid type, owing to the absence of calcium carbonate, and in moist situations, or where the clay becomes somewhat heavier, there is a gradual transition to the marsh formation. An intermediate phase occurs in some pastures where *Juncus* species become dominant. The following list gives some idea of the principal species found on these soils:—

Crataegus oxyacantha.
Rubus spp.
Anthoxanthum odoratum.
Alopecuris pratensis.
Holcus lanatus.
Poa pratensis.
P. nivialis.
Luzula campestris.
Ranunculus repens.
R. acris.
Ranunculus Ficaria.
Sinapis arvensis.
Galium aparine.
Centaurea nigra.
Cnicus arvensis.
Bellis perennis.
Plantago lanceolata.
P. media.
Orchis morio.
O. maculata.
Cynosurus cristatus.
Dactylis glomerata
Lolium perenne.
Bromus mollis.
Phleum pratense.
Agrostis alba.
A. repens.
Carex panicia.
C. sylvaticium.
Cardamine pratensis.
Lychnis Flos-culcili
Genista tinctoria.
Potentilla anserina.
Spirea Ulmaria.
Primula vulgaris.
Tussilago Farfara.
Senecio vulgaris.
Rumex crispus.
R. acetosa.
Equisetum arvense.
and Caltha palustris.

The dividing line between the vegetation of damp clays, alluvial soils, and so to typical marshland, is never

easy to draw, and in this district the difficulties are intensified by the smallness of the areas.

Aquatic Formation.

So little ecological work has been done on the associations of fresh and stagnant water that detailed classification is impossible. Two types of habitat can be distinguished, that of slowly-flowing water along the numerous small streams of the clay lands, and that of the pits and ponds. Throughout the district on the glacial clays are to be found 'marl-pits,' relics of the days when clay was regularly dug and spread over the lighter loams.

A definite zonation is found in the pits, whilst the pits themselves, of various ages, show a continuous transition from bare sheets of water, to those displaying distinct zones of vegetation, which, spreading from the margins inwards, gradually fill up the pit and leave only a slight depression in the ground occupied by marsh plants. Some of the more commonly occurring species in and around the pits, in addition to those already given for dry lands, are:—

Salix alba.
S. fragilis.
Salix viminalis.
S. cinerea.
S. aurita.
Crataegus oxyacantha.
Thalicum flavum.
Ranunculus Drouetti.
R. heterophyllus.
R. peltatus.
R. Baudotii.
R. sceleratus.
R. flammula.
Caltha palustris.
Nymphea alba.
Hottonia palustris.
Scrophularia nodosa.
S. aquatica.
Mentha sativa.
M. hirsuta.
Elodea canadensis.
Juncus bufonius.
Sparganum ramosum.
Nasturtium officinale.
N. palustre.
Cardamine pratensis.
Lychnis Flos-culcili.
Hypericum quadratum.
Spirea Ulmaria.
Potentilla Comarum.
Hippuris vulgaris.
Myriophyllum spicatum.
Lythrum Salicaria.
Epilobium hirsutum.
E. parviflorum.
Sium erectum.
Œnanthe fistulosa.
Gnaphilium uliginosum.
Symphytum officinale.
Veronica Beccabunga.
V. anagallis.
Polygonum amphibium.
Rumex Hyrolapathum.
Iris pseudacorus.
Typha latifolia.
Lemna minor.

and Alisma plantago, etc.

Vegetation of Sand and Sandstones.

Just as the natural oaklands pass by almost insensible steps to fresh water marsh with increasing water content of the soil, so in the opposite direction the vegetation of the lighter loams passes gradually into dry oak-birch association and heath. As a consequence of the complex mixtures of soil to be found in the area any definite subdivision of the resultant plant formations is impossible. Again, most of the light soils, except those of the coarsest description, have been under continuous arable cultivation, reducing the natural vegetation to a minimum.

The dry, sandy grasslands include such species as:—

Antboxanthum odoratum.
Festuca ovina.
Aira caryophylea.
A. praecox.
Bellis perennis.
Achillea millefolium.
Deschampsia flexuosa.
Agrostis canina.
A. vulgaris.
Lotus corniculatus.
Ranunculus spp.
Potentilla procumbens.

whilst on arable land common 'weeds' are:— *Spergularia arvensis, S. rubra, and Rumex acetosella.*

The finest examples of the heath formation are to be found at Irby and Thurstaston in North Wirral and on the Helsby and Overton hills. On the hillsides immediately behind Helsby and Frodsham and on thin peat occur:—

Pteris aquilina.
Vaccinum myrtillus.
Deschampsia flexuosa.
Calluna erica.
Galium saxatile.
Ulex europaeus.
Erica cinerea.
Rubus dasyphyllus.

The Irby-Thurstaston Heath land contains an interesting patch of woodland with *Betula alba* dominant, intermixed with *Pinus sylvestris*, self-sown from the neighbouring plantations. As this woodland thins out to the south-west the ground vegetation, comprising—

Calluna vulgaris. l.d.
Erica cinerea.
E. tetralix.
Pteris aquilina l.d.
Potentilla procumbens.
Rumex acetosella.
and Ulex gallii. l.d.

increases in extent, forming a belt between the woodland and a large area of *Molinia caerulea.* The

Molinia heath appears to be extending at the expense of the *Callunetum*, probably as a result of frequent fires, which occur several times a year during the tourist season. It has been repeatedly noticed that whilst the *Callunetum* and *Betuletum* suffer severely from this cause the outer leaves only of *Molinia caerulea* are destroyed, the compact tussocks of younger leaves holding the moisture, and except in very severe fires, remaining green after the remainder of the vegetation has been reduced to ashes. The pathways over the heath are fringed with *Festuca ovina*, the only plant capable of standing the trampling, though when the traffic is concentrated in the centre of the pathway even this hardy plant gives way, leaving a narrow ribbon of silvery sand. The peat is strongly acid, whilst under the surface the original red sandstone is bleached by removal of ferruginous material which tends to accumulate in the form of 'pan.'

At the eastern side of the Heathland the vegetation changes somewhat abruptly. On the upper levels of Thurstaston Hill *Festucetum ovina* occurs, with accompanying patches of *Juncetum* in hollows. The slopes of the hill towards the Dee and as far as the boundary of cultivated lands to the North have been repeatedly swept by fire, from which *Pteris aquilina* has not yet recovered. A noteworthy plant is *Epilobium angustifolium*, which stands out against the burnt surface of the degenerating peat. The principal species occurring are:—

Lichens.

Lecidea granulosa.
L. uliginosa.
Cladonia furcata.
C. squamosa.
C. Floerkiana.
Cladina sylvatica.
C. uncialis
Cetraria islandica.
C. aculeata.
Parmelia physodes.

The principal mosses on dry peat throughout the heath area are:—

Polytrichum piliferum.
P. juniperinum.
Ceratodon purpureus.
Hypnum Schreberi.

Occasional patches of boggy ground occur in which may be found:—

Carex binervis.

Drosera rotundifolia.	Eriophorum vaginatum.
Phragmites communis.	Juncus spp.
Sphagnum compactum.	Campylopus flexuosus.
S. cuspidatum.	Dicranum scoparium.
S. inundatum.	Leucobryum glaucum.
S. crassicladum.	Hypnum fluitans.
S. papillsum.	H. cupressiforme v. erictorum.
Polytrichum formosum.	Gymnocolea inflata.
P. commune.	Cephalozia connivens.

The presence of a thin band of clay running across the heath can be readily traced by the more mesophytic type of vegetation; *Potentilla anserina* being characteristic with a shrub layer of *Crataegus oxyacantha* and *Rubus spp.* Wherever the surface has been disturbed by man, for example in the quarry at Irby Mill Hill, the dominant plant is *Ulex europea* with *Cytisus scoparius*, *Calluna*, *Festuca ovina*, etc., in the open spaces. After frequent fires there springs up a dense growth of *Rumex Acetosella*, with *Epilobium angustifolium*, which holds its own until again destroyed by *Ulex*.

Sea Coast Vegetation.

The chief formations are those of the sand hills and salt marshes, whilst the sandstones and clays([10]) subject to marine influences bear distinctive associations.

The Sand Hills.

The sand dunes or sand hills bordering the coast line are certainly one of the most interesting areas to the ecologist. In Cheshire they never developed to so great an extent as their neighbours on the Lancashire coast. Certain differences exist between the formations on either side of the Mersey which merit their separate treatment.

In Cheshire the sand along the shores of Liverpool Bay is continually pushed inland by wave motion, whilst the portion lying between high and low water marks is steadily carried inland by wind above the reach of the tides. Considerable modifications of this unstable coast line, so formed, have been induced by

alongshore currents, so that the belt of dunes which formerly stretched from the Dee to the Mersey has been so reduced in extent that the central portion, between Leasowe Castle and Meols, has been entirely removed. The portions remaining to the East and West are linked up by the Wallasey Embankment, erected in 1829 to keep the sea from flooding the alluvial plain behind.

Where the dunes are not subject to erosion, notably between Harrison Drive, Wallasey, and New Brighton, a strand flora, forming a miniature dune system, has existed more or less sporadically amongst the shingle and tidal refuse. The chief colonisers along this area have been :—

Agropyron junceum.
Cakile maritima.
Salsola kali.
Glaux maritima.

with occasional tufts of Marram grass (*Ammophila arenaria*). Since the construction, during the past winter, of a low wall along the shore, this incipient dune system has been destroyed.

Behind the strand association rose the outer dune belt, hills of sand sparsely colonised by Marram grass forming typical 'white dunes' up to 40 feet in height. The landward face became more compact with the addition of :—

Festuca rubra.
Phleum arenarium.
Agrostis alba.
Senecio Jacobea.
Sonchus spp.
Eryngium maritimum, etc.

and Taraxacum ap.

Further inland there is a gradual transition through a phase of 'Grey Dune' to 'Dune Pasture,' now occupied and extremely modified as golf links. Typical plants are :—

Rosa spinosissima. l.a.
Rubus caesius.
Sedum acre. l.a.
Galium verum.
Senecio Jacobea.
Erythrea littoralis.
Thymus serpyllum.
Myosotis collina.
Salix repens.
Carex arenaria.
Phleum arenarium.
Aira caryophyllea.
A. praecox.
Fumaria officinalis.
Hieracium umbellatum.
Lotus corniculatus.
Ononis repens (under Salix).
Brassica monensis.
Rumex acetosella.
Plantago maritima.
Medicago maritima.
Euphrasia officinalis.
Viola canina.
V. curtisii.
Bartsia viscosa.
Arabis hirsuta

Convolvulus soldanella.

The continued erosion of the seaward face of the dunes caused a gentle slope of about 30° to become an almost vertical cliff. Frequent falls of sand and turf have taken place, until near Leasowe Castle, the inner grey dunes are now distinctly exposed to the sea. This loosening of sand on the inner dunes and the prevalence of high winds carrying sand over the dune pasture and into the ' slack,' together with the depredation of numerous summer ' trippers,' created a situation with which the existing flora was unable to cope.

The Wallasey Corporation, having given up the method of planting Marram grass and erecting timber barriers, have levelled portions of the area, and covered the loose sand with ashes, town refuse and clay. On this carefully-prepared bed has been sown grass seeds, principally Rye Grass (*Lolium perenne*), whilst the seaward face is protected in part by a low wall, trespassers being restrained by suitable fencing. Considerable areas still remain over which the interesting struggle for existence of the dune flora can be seen. The advance of sand, when gradual, permits of the continued growth of a much simplified inner dune association ; in greater quantity, however, the sand completely destroys the gramineous species with the exception of *Ammophila*, whilst *Salix repens* shows considerable powers of resistance. Some plants, not generally considered to be active arresters of moving sand, for example, *Equisetum variegatum* and *Galium verum* prove quite effective, the former by ramifying in all directions over the surface, whilst the latter form little tussocks developing into miniature dunes up to a foot in height. *Campanula rotundiflora* and *Achillea millefolium* also survive in the invaded region to a certain extent.

Salt Marsh Formation.

The gradual silting up of the estuary of the Dee, a process which has certainly been in progress since 1500, if not before, has led to the formation of a most interesting area of salt marsh. These marsh lands

extend from Chester to Parkgate, a distance of some seven or eight miles, the navigable channel of the river being carried along the coast of Flint as far as Connah's Quay. The typical salt marsh formation, however, attains its maximum development between Parkgate and Burton, and shows many features in common with those described elsewhere in the country. The formation at its seaward extremity first appears as isolated clumps consisting chiefly of *Glyceria maritima*, *Cochlearia anglica*, together with *Armeria maritima*. Further inland these gradually coalesce to a matted turf of *Glyceria*.

Still further inland and at a higher level the turf is composed of *Glyceria* with *Festuca rubra* in increasing quantity, whilst the whole association becomes more varied, containing a larger number of plants, of which the following species are typical:—

Glaux maritima.

Plantago maritima.	Suaeda maritima.
P. coronopus.	Juncus Gerardi.
Spergularia media.	Triglochin maritimum.
S. marginata	Armeria maritima

The peculiarities of salt marshes in their zonation and the almost pure associations are well represented in this area, but their constant sequence is to some extent disturbed by the frequent occurrence of deep sea channels, which, with their mobile character, often lead to the formation of 'pans,' in which *Salicornia herbacea*, *Statice limonium*, *Sueda fruticosa*, and numerous algae may be found. As the salt marsh gradually develops into firmer ground, embankments or 'cops' have been erected from time to time in order to preserve the land for agricultural purposes.

Along the landward side of the marsh, fresh-water streams, draining from the clay cliffs, flow over the marsh land, and along some of these small creeks there is frequently to be observed a gradual transition in the composition of the flora as the water gets more and more brackish.

Ranunculus heterophyllus.	Scirpus maritimus.
Juncus Gerardi.	Nasturtium officinale.
J. maritima.	Equisetum limosum.

are typical species. Near Shotwick the vegetation approaches the normal inland type.

At Stanlow Point in the Mersey estuary there occurs a small patch of the salt marsh formation which is quite distinct from that at Burton. The area can be distinctly divided into two zones, roughly consisting of a pure association of *Glyceria maritima* of exceedingly luxuriant growth, whilst the high marsh is composed of the ordinary matted, stunted form of the same plant which gradually passes over into *Festuca rubra*. The flora here is remarkably poor, many of the species occurring at Burton are here absent or only occasionally represented. The most conspicuous being:—

Plantago maritima. **Scirpus maritimus.**
Atriplex hastata. **Glaux maritima.**

A similar patch of salt marsh of smaller extent occurs on the opposite shore, on Dungeon Marsh.

Marine Algae.

The characteristic zoning is obscured to a great extent, on the South Lancashire and Cheshire coasts, from the nature of the substrata. A firm rock surface is only exposed in a few places, notably Hilbre and Hilbre Point, New Brighton, Eastham, and Stanlow on the Cheshire side, and this fact, coupled with the large amount of silts and muds deposited in and around the estuaries of the Dee and the Mersey, render the flora somewhat poor. It has been noticed that at Hilbre those forms usually occurring on the lower levels, below high water mark, for example the *Rhodophyceae*, are practically absent, as the rock surface here is covered with soft muds; on the other hand, the *Phaeophyseae* are well represented wherever conditions permit of their establishment.

Associations of *Fucus serratus*, *Fucus vesiculosis*, *Ralfsia verrusosa*, etc., are flourishing. *Fucus serratus* is also reported in the open creeks on the salt marshes at Burton. In addition to the large amount of fine silt, especially in the Mersey estuary, chemical wastes

are to a certain extent held responsible for the peculiar flora conditions. The contrast between the salt marshes at Stanlow Point, in the Mersey estuary, and those at Burton, is possibly due to this circumstance.

Coastal Rock Associations.

At several points along the coasts and estuaries there occur small areas of rock free from drift or blown sand. The most notable are those at Hilbre, where an interesting flora is found. Interesting typical species are:—

Festuca rubra.
Erodium maritimum.
Arenaria peploides.
Plantago coronopus.
Rumex crispus.
Lotus corniculatus
Galium verum.
Thalictrum minus.
Armeria maritima.
Spergularia rupestris
Silene maritima.
Asplenum maritima.
Xanthoria parietina.
Placodium murorum.
P. lobulatum.
P. ferrugineum v. festivum.
Leacanora atra.
L. umbrina.
L. atrynea.
L. parella.
Lecania prosechoides.
L. erisbye.
Lecidea lithophilla
Opegrapha calcarea.
O. confluens.
Verrucaria maura.

THE SOUTH LANCASHIRE PEAT MOSSES.

J. A. Wheldon, M.Sc., and W. G. Travis.

The deep-bogs, locally called 'Mosses,' are now rapidly disappearing. At the present time only a few scattered parts of mossland are left and they exist only in a more or less drained and altered condition. These peat-mosses, with a great thickness of acid peat, correspond with the 'Hochmoor' of German botanists. They were deepest at the centre, thinning out towards the margins, and thus presented a slightly domed upper surface in section. They, in all cases, seem to lie on a sandy deposit, the Shirdley Hill Sand.

Two separate and distinct areas of mossland exist within the district. The first of these occupies the very low-lying land drained by the River Alt and its tributary, the Downholland Brook. This ground stands at an elevation of only 10 to 20 feet above O.D., and is shut off from the sea by the belt of coastal dunes

At many places remains of oak and Scots pine (*Pinus sylvestris*) have been found at the base of the peat. These forest remains are stated by local geologists to be continuous with the well-known 'Peat and Forest Bed' that is exposed on its shore at the mouth of the River Alt.

A second formerly extensive area of mossland, standing at a higher elevation (150-200 feet) above sea level, lies at the western foot of the hilly ridge of Ashhurst Beacon and Billinge Hill, comprising Simonswood and Rainford Marshes, Holland Moss, and the mosses about Skelmersdale. On Simonswood Moss the peat was found to be 30 feet thick. The plant-association on these peat-mosses in their undrained condition was a Sphagnetum, with the cotton-grasses, *Eriophorum vaginatum* and *E. angustifolium* and associated spp. *Drosera rotundifolia* and *Narthecium ossifragum*, etc. This type of plant association with its rich growth of *Sphagna* and other bryophyta, which flourishes on a wet spongy, undrained peat-moss, is apparently no longer to be found in the area; and only the vegetation that occurs during the various stages of desiccation, due to artificial drainage, is now available for study. In the first stage of desiccation the Sphagnetum is converted into a cotton-grass association, consisting mainly of *Eriophorum vaginatum*, with some *E. angustifolium*, *Molinia caerulea* or *Calluna* (or both) occurring in quantity on its marginal or better-drained portions. The replacement of the Eriophoretum by a Molinietum may be regarded as evidence of the second stage of the desiccation process.

During drying of the moss there is usually an invasion of birch, *Betula alba* and *B. tomentosa*, accompanied by more or less Bog Myrtle (*Myrica Gale*). Before the Molinietum or a *Molinia* and *Calluna* association has become established some of the flowering-plants, such as the *Sundews*, *Narthecium ossifragum* and *Rhynchospora alba*, as well as many of the bryophytes, have disappeared.

Evidence of the former extent of the mosses is generally afforded by the black, peaty soil, and the deep ditches where many of the mossland plants still linger. The unreclaimed mossland frequently stands five or six feet higher than the cultivated fields which have been reclaimed from it, thus showing the thickness of peat which has been pared away.

Usually the ditch-banks in the immediate proximity of the moss are dominated by *Molinia caerulea* and a few birches, *Betula alba* and *B. tomentosa*, are generally to be seen along the ditches and spreading over the drier parts of the adjacent moss. The following is a list of species noted on the ditch-banks and other undisturbed peaty ground about mossland in the Rainford district:—

Molinia caerulea.
Agrostis tenuis.
Rumex acetosella.
Epilobium angustifolium.
Betula tomentosa.
B. alba.
Rhamnus frangula.
Galium saxatile.
Pteris aquilina.
Calluna vulgaris.
Myrica Gale.
Anthoxantham odoratum
Senecio sylvaticus.
S. Jacobaea.
Potentilla Tormentilla.
Luzula multiflora.
Holcus lanatus.
Lastrea dilatata.
L. spinulosa.
Athyrium Filix-foemina.
Rubus plicatus.
Viola lepida.
Lotus uliginosus.
Pyrus ancuparia.
Carex Goodenowii.
C. ovalis.
Juncus effusus var. compactus.
Aira praecox.
Salix cinerea.
Teucrium Scorodonia.
Rumex acetosa.
Ulex europaeus.
Hieracium boreale.
H. umbellatum.
Hypochaeris radicata.
Vicia Cracca.
Digitalis purpurea.
Trifolium minus.
Rubus Idaeus.
R. pulcherrimus.
R. Selmeri.
R. fissus

On the bare peat of these ditch-banks the moss *Dicranella cerviculata* is usually present in great abundance, and *Webera nutans* is also very common. *Cephalozia bicuspidata*, *Calypogeia Trichomanis*, and *Gymnocolea inflata* are the principal Hepatics on the moister parts. The barer peat on the upper part of the banks is often coated with a thick crust of lichens consisting mainly of *Lecidea uliginosa*, *L. decolorans* and *Cladonia spp.*

THE LANCASHIRE SAND DUNES.

J. A. Wheldon, M.Sc., and W. G. Travis.

In South Lancashire it is possible to watch the development of the dune flora from its origin on the seashore, through various unstable phases, to stabilised heathland or dune-pasture.

Originally these dunes extended in crescentic form from Bootle to Churchtown, north of Southport, a distance of about sixteen miles, their breadth varying from one half to two miles. Even in their present reduced state this belt of dunes is more extensive and possesses a richer flora than any on the English coasts.

The hills built up by the Marram grass follow the coast line in many parts, the ridges running north and north-east in a series of parallel lines. Between them lie valleys or slacks, some dry, some moist, and others marshy or very wet. The larger slacks formerly contained extensive pools of water, which were sometimes deep in the middle even in summer. Only a few comparatively small sheets of water now remain, and the whole area presents more arid conditions than was the case even thirty years ago. This is due largely to the system of trenches cut for drainage, and perhaps also to a general increase of the thickness of the sand deposit in the hollows by the levelling agency of the wind.

The proportion of halophytic species is reduced as the distance inland increases; and also on the stable inland dunes, the proportion of calciphile species becomes smaller.

I. *The Strand Flora.* From Formby to Birkdale there is an entire absence of shingle or salt-marsh. Stones are practically absent on the whole dune tract. Many well-known halophytes typical of shingle beaches, or mixtures of shingle and sand, do not occur, and the few shore plants lead a precarious existence, owing to the mobility of the sand. Where silt is practically absent, as between Ainsdale and Birkdale, *Agropyren*

junceum is the pioneer species, and it forms a long low barrier in front of the dunes. When there is more or less admixture of mud or silt, the ridging process may originate with *Agrostis alba var. maritima*. These species are here and there sparingly interspersed with:—

Cakile maritima.

Salsola Kali.	Atriplex hastata.
Arenaria peploides.	Atriplex arenaria (rare).

More generally, however, this group of psammophilous halophytes is not represented, owing to the use of barriers and the planting of star-grass on the sand collected by them. This brings the Marram dune right on the strand, and it may then be entirely free from all the species named. This strand flora contains no bryophytes, lichens nor higher fungi.

II. *The Ammophiletum arenariae* (outer series). *Ammophila arenaria* is dominant, and *Agropyron junceum* for a time subdominant. Very rarely, near Formby, *Elymus arenarius* is the dominant species. The first line of outer dunes is comparatively low, but grows rapidly, in a few years attaining a height of six to ten feet. By this time a few other plants have obtained a hold on the lee side, but as yet there is no fixation of the surface and the association is very open. Prominent amongst the early colonists are plants with wind-borne fruits:—

Senecio Jacobaea.	Cirsium arvense.
Senecio vulgaris var. radiatas.	Carlina vulgaris.

and they are soon reinforced by

Euphorbia Paralias.

Euphorbia portlandica.	Viola ericetorum.
Lotus corniculatus var. crassifolius.	Erophila verna.
Cynoglossum officinale.	Erophila praecox.
Cerastium tetrandrum.	Festuca membranacea.
C. semidecandrum.	Phleum arenarium.
Eryngium maritimum.	Convolvulus Soldanella.

When the decay of the grasses, etc., has provided a little humus, Bryophyta soon appear, consisting of a few patches of

Barbula convoluta.	Ceratodon purporeus.
Tortula arenicola.	Brachythecium albicans.

These are able to withstand burial by readily throwing

up innovations, and they thus assist in stabilising the surface. Neither lichens nor hepaticae occur, but a few of the higher Fungi now make their first appearance. Amongst these are *Inocybe rimosa*, *Tulostoma mammosa*, *Tubaria furfuracea var. trigonopylla*. By this time the hollow behind the dune will have begun to show the initial stages of the Dune Marsh Flora to be noticed presently. Beyond this shallow valley a higher line of Marram dunes will be found, and in some places this alternation of dune and valley is repeated several times, especially between Formby and Ainsdale.

III. *The Ammophiletum arenariae* (second series). On these dunes the first indications of a lichen flora appear, decaying mosses and marram stools providing a matrix for *Leptogium scotinum*, which fruits well, and two or three species of *Cladonia*, but it is too dry for hepatics. Fungi are very rare, except where the dunes have been planted with *Pinus*, *Betula*, *Alnus*, *Populus*, etc., when numerous Agarici and Boleti occur. In the natural state there is little beyond *Inocybe rimosa*. All the flowering plants referred to in the first series of dunes may be found with the addition of:—

Hypochaeris glabra.
Taraxacum obliquum.
T. laevigatum.
Sedum acre.
Erodium neglectum.
Valerianella olitoria.
Polygala oxyptera.
Anthyllis vulneraria.
Saxifraga tridactylites.
Lotus corniculatus var. crassifolium.
Viola Curtisii.

The Brya already named are more abundant, and amongst others may be found the following species:—

Ceratodon conicus.
Barbula vinealis.
B. Hornschuchiana.
B. rubella.
Trichostomum flavovirens.
Leptobryam pyriforme var. minus.
Brachythecium velutinum.
Tortula intermedia.
Bryum inclinatum.
Bryum pendulum.
Bryum argenteum (rare).
Camptothecium lutescens (rare).
Hypnum cupressiforme var. tectorum.

These outer dunes sometimes reach a height of 50 feet above ordnance datum, or higher.

IV. *The Ammophiletum arenariae* (inner series). Inland, behind the wide range of outer dunes, already described, lie the wider and more important of the dune valleys, and on their landward side is found the older line of more stable, fixed or inner dunes. They also are very extensive and variable in their contours and height, but commonly from 40 to 80 feet above ordnance datum. Inland they gradually pass into dune-pasture or grass-land.

Marram grass is still the dominant plant where the dunes are left in a natural state, and most of the plants described as occurring on the outer dunes occur on these also, but not *Eryngium maritimum*, *Viola Curtisii*, *Euphorbia sp.* or *Agropyron junceum*. Grasses are frequent, especially

Festuca rubra.
Festuca ovina.
Festuca sciuroides.
Bromus mollis.

and occasional bushes of *Salix rubra*. Sometimes the hills are clothed with *Rubus caesius* with occasionally *Sambucus nigra*.

Species which are not found on the shoreward dunes already described are now seen, including:—

Diplotaxis muralis.
Sagina apetala.
Arenaria serpyllifolia.
Arenaria leptocladus.
Trifolium avense.
Filago minima.
Galium verum.
Cuscuta epithymum.
Hieracium pilosella.
Hieracium umbellatum.
Echium vulgare.
Euphrasia nemorosa.
Thymus serpyllum.
Equisetum arvense.
Ceratodon purpureus.
Tortula subulata.
Bryum caespiticium.
Bryum capillare.
Bryum inclinatum.
Bryum argenteum.
Dicranum scoparium.
Brachythecium velutinum.
Hypnum cupressiforme.
Eurynchium megapolitanum.
Encalypta streptocarpa.
Ditrichum flexicaule (rare)
Trichostomum tortuosum (rare).
Hylocomium triquetrum and
Mnium stellare (rare).

Lichens are frequently in some abundance, and include eight species of *Cladonia*, two of *Peltigera*, *Parmelia physodes*, *Cetraria aculeata* and *Bacidia latebricola* (12). Fungi abound in the planted areas, including far too many species to enumerate here, chiefly of the genera *Lepiota*, *Gomphidium*, *Tricholoma*, *Lactarius*, *Boletus*.(13).

V. *Dune grassland or pasture* is with us restricted to a narrow tract lying between the stable inner dunes and the area of cultivation. It is much interrupted and hardly anywhere uninterfered with. It contains many of the constituents of ordinary pasture, which dispute supremacy with the now rapidly disappearing Ammophila. The *Cerastia* of the inner dunes occur, but are giving place to *C. viscosum* and *C. triviale*, and occasionally *C. arvense* may be found.

Taraxacum officinale.
Agropyron repens.
Aira praecox.
Sieglingia procumbens.
Ranunculus bulbosus.
R. acris.
Vicia lathyroides.
V. Bobarti.
V. cracca.
Veronica arvensis.
Arenaria serpyllifolia.
Crepis virens.
Achillea Millefolium.
Campanula rotundifolia.
Verbascum thapsus.
Galium verum.
Luzula campestris.
Festuca ovina.
F. rubra.
Agrostis vulgaris.

Amongst the cryptogams may be noted *Polytrichum juniperinum* and *Cetraria aculeata*. In the disturbed portions alien plants sometimes colonise the ground, and some of them spread extensively. The more striking of these are:—

Œnothera biennis.
Œ. Lamarckiana.
Sisymbrium pannonicum.
Hieracium brunneo-croceum.
Campanula rapunculoides.
Saponaria officinalis var. puberula
Claytonia perfoliata.
Asparagus officinalis.

The last is sometimes possibly native, but it so frequently cultivated here that the point is difficult to determine.

VI. *Dune-heath.* Very rarely is the dune-pasture allowed to degenerate into dune-heath, but between Freshfield and Ainsdale characteristic examples of the beginnings of such an association may be found. It is perhaps only in a transition stage, and will probably never be allowed to attain complete development. Its facies is entirely different from that of the groups already considered. Scattered bushes of *Calluna Erica* and *Ulex europaeus* are prominent, with very rarely *Erica tetralix*. Other characteristic heath plants which

indicate the almost total leaching out of the lime from the soil are:—

Galium Saxatile.
Cytisus Scoparius.
Oxalisacetosella.
Nardus stricta.
Potentilla procumbens.
Campanula rotundifolia.
Polygala depressa.
Carex arenaria (in plenty).
Juncus effusus.
J. conglomeratus.
Aira praecox
A. caryophyllea.
Briza media.
Webera mutans.
Dicranum scoparium
Dicranella heteromalla.
Hypnum cupressiforme var. ericetorum.
Cladonia (including C. Coccifera).
L. granulosa.

Juncus squarrosus.
Luzula campestris.
Carex ovalis.
Teesdalia nudicaulis.
Ornithopus perpusillus.
Hypochaeris radicata.
Thrincia hirta.
Holcus mollis.
H. lanata.
Sieglingia procumbens.
Anthoxanthum odoratum.
Poa pratensis.
Polytrichum formosum.
P. piliferum.
P. juniperinum.
Campylopus pyriformis.
Cephaloziella bifida.

Lecidea uliginosa.
Salix repens (scattered sparingly).

VII. *Dune-Pan or 'Slacks.'* The depressions amongst the dunes vary greatly in depth, and in moisture, and may be seen entirely devoid of vegetation when first formed, through various very open associations of plants to the dense closed associations found in the more inland type.

(*a*) *The Halophytic dune-pan.* Behind the first rampart of dunes there is formed a valley, at first somewhat shallow, the bed of which becomes more or less uneven through receiving sand from the dune lying to the seaward side. In time the surface becomes discoloured by the deposition of ferric hydroxide, probably due to the action of iron bacteria, and soon after a few minute algae and young plants of *Bryum* spring up.

In ground so prepared there soon appear scattered tufts of

Agrostis alba var. coarctata.
Sagina nodosa var. monilifera
*Glaux maritima.

F. minima.
Salix repens.
*Ranunculus sceleratus.
Plantago maritima.
Holcus lanatus.

*Juncus articulatus var. littoralis.
J. ranarius.
Apium nodiflorum var. pseudorepens.
Ranunculus Flammula.
Erythraea littoralis.
Carex Œderi.
*Triglochin maritima.
Atriplex hastata.
Phleum pratense.

These species were all noted by one of us (9) in a

commencing slack within about 12 months of the time when it was a mere unenclosed portion of the sandy shore. The halophytes or semi-halophytes are marked with an asterisk, and they, or some of the following, occur in all this type of early dune marsh, viz. :—

Juncus maritimus.
J. Gerardi.
Scirpus maritimus.
S. rufus.
S. pauciflorus.
Aster tripolium.
Apium graveolens.
Sagina maritima.
Œnanthe Lachenalii.
Carex distans.
C. vulgaris.
C. extensa.

As the sea recedes and the dune barrier increases in height the halophytic element tends to disappear, and by the time a new outer barrier has arisen, none of them may remain. The last to disappear is usually *Juncus maritimus*. The salt marsh species no doubt owe their existence to the comparatively low outer-dune rampart, which allows free access to spray from the sea.

(*b*) *The Bryum Association* is a very characteristic group which sometimes completely covers the floor of the smaller slacks, or in the larger, surrounds the margins of pools or the denser vegetation of dune marsh(18). It forms an exquisite carpet of red, brown, pale and olive green, studded with miniature forests of red setae of

Bryum pseudo-triquetrum.
B. pendulum.
B. calophyllum.
B. Warneum.
B. inclinatum.
B. pallens.
B. intermedium.
B. lacustre.
B. neodamense.
B. fallax.
B. uliginosum.
B. Marrattii.

the last four being comparatively rare. These are soon joined by other mosses, one or other of the following preponderating according to the conditions of moisture and shade :—

Barbula tophacea.
B. rubella.
B. vinealis.
Amblyodon dealbatum.
Swartzia inclinate.
Campylium polygamum.
Brachythecium Mildeanum.
Amblystegium serpens var salinum.
Preissia quadrata.
Reboulia hemisphaerica.
Petalophyllum Ralfsii.
Aneura pinguis.
A. major.
Pallavicinia Flotowiana.
Pellia Fabbroniana.
Lophozia badensis

Flowering plants invade this type of slack, of which the more frequent are:—

Carex arenaria.
Juncus articulatus.
Samolus Valerandi.
Rumex obtusiflorus.
Erythraea littoralis.
E. pulchella.
Helosciadum inundatum.
Caltha palustris.
Parnassia palustris var. condensata
Pedicularis palustris.
Chlora perfoliata.
Pinguicula vulgaris (rare).
Orchis incarnata.
Hydrocolyte vulgaris.

(*c*) *The Harpidium Association* is restricted to wetter hollows in which water lies more or less permanently on the surface. Here the *Brya* give way before the domination of certain large species of the *Hypnaceae*(18). Owing to the general drier conditions now prevailing on the sand hills tract, this type of hollow is much more limited in extent than was formerly the case, and will probably be the earliest to disappear. Where the surface is merely marshy and without pools, these mosses form a spongy carpet sometimes entirely covering the floor of the slack. Where pools occur, they surround them in a wide zone, and also penetrate far into the pools, as they thrive equally well when entirely covered by water. When marginal they form a suitable habitat for *Anagallis tenella*, *Helleborine longifolia* and other plants, and may be mixed with other mosses, such as *Amblyodon dealbatus*, *Meesea uliginosa* or *Philonotis calcarea*. The dominant species, however, is either *Drepanocladus lycopodioides*, *D. Wilsoni*, or *Hypnum cuspidatum*, and several or all the following usually occur in some plenty also:—

Drepanocladus Sendtneri.
D. pseudofluitans.
Limprichtia revolvens.
Campylium polygamum var. stagnatum.
Brachythecium Mildeanum.
Scorpidium scorpioides.
Climacium dendroides.
D. aduncus.
Limprichtia intermedia.
Cahpylium elodes.
Amblystegium filicinum var. Whiteheadii.
Calliergon giganteum.
Campylium stellatum

(*d*) *The Dune-marsh Pool Sub-association*, referred to above, is now only to be found in a well-developed state in a few places. It almost always shows a fairly

regular zonation, the centre being occupied by Charads.

Chara foetida.
C. hispida.
Potamogeton natans.
C. contraria.
C. aspera.
P. heterophyllus.

Beyond these occasionally occur *Equisetum limosum*, and mingling with the invading carpet of the previously-described

Eleocharis palustris,
Menyanthes trifoliata.
Equisetum variegatum.
Selaginella selaginoides.
Typha latifolia.
E. uniglumis.
Mentha hirsuta.
Littorella uniflora.
Scirpus Savii.
S. Tabernaemontani.

In quite exceptional cases a reed swamp is formed at one margin, with which may even be found a few plants of *Eriophorum angustifolium* and beds of Scirpus *maritimus var. conglobatus*.

Slacks which are too dry or too young to fall into any of the before-named groups are very numerous, and they are almost invariably dominated by *Salix repens*.

(*e*) *The Salicetum repenti* occupies almost as great an area as the Marram grass dunes, in the valleys between which it builds up secondary dunes around the bases of the latter.

Around the *Salix* hills are occasionally found still smaller tertiary hillocks built up by *Carex arenaria* and *Agrostis palustris*. In such a situation, dominated by *Salix repens*, may be found:—

Cardamine pratensis.
Epilobium parviflorum.
Senecio Jacobaea.
Hieracium umbellatum.
Leontodon autumnalis.
Thrincia nudicaule.
Monotropa hypopithys var. glabra.
Pyrola rotundifolia var. maritima.
Gentiana baltica.
Rhinanthus stenophyllus.
Ajuga reptans.
Helleborine viridiflora.
Ophrys apifera (rare).
Luzula campestris.
Carex flacca.
C. goodenowii.
Festuca rubra.
Lotus uliginosus.
Lythrum salicaria.
Hypericum quadratum.
Taraxacum officinale.
Inula vulgaris.
Carlina vulgaris.
Erythraea centaurium.
Gentiana amarella.
Odontites rubra.
Mentha hirsuta.
Listera ovata.
Orchis incarnata.
O. praetermissa.
O. pryamidalis (very rare).
Carex arenaria.
Agrostis alba.
Holcus lanatus.

It may be noted as indicating the increased acidity of the soil induced by the dense vegetation of these Salix 'thickets' that in one such slack near Formby

we find a thriving colony of *Sphagnum plumulosum*, accompanied by *Aulacomnium palustre*. Where *Salix repens* is more sparsely scattered, three mosses are very often found carpeting the soil under its shelter, viz., *Brachythecium rutabulum*, *Eurynchium praelongum*, and *Amblystegium serpens*.

(*f*) *The Dune Ditch Flora*. This has not been systematically studied, but the ditches nearest the sea are very slightly brackish. They intersect the dunes in various directions and have been instrumental in materially affecting the Flora of the slacks. In them, however, are preserved many species growing scarcer every year in the modified Dune marshes. The sides of the ditches are rich in mosses, and their beds rapidly become choked with growths of *Drepanocladus lycopodioides* and other *Hypna*, and *Charads*. They also yield:—

Ranunculus Baudotii.
R. trichopyllus.
R. Flammula.
Apium inundatum.
Œnanthe fistulosa.
O. Lachenallii.
Veronica anagallis.
Mentha hirsuta.
Scutellaria galericulata.
Alisma plantago.
A. ranunculoides.
Juncus bulbosus.
Potamogeton heterophyllus.
Sium erectum.
Valeriana dioica.
Equisetum limosum.
E. palustre.

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THE ENTOMOLOGY OF THE LIVERPOOL DISTRICT.

(The Late) W. E. Sharp.

(Revised by W. Mansbridge, J. R. le B. Tomlin, and R. Newstead.)

General Distribution in this Country of the Class Insecta.

The insect fauna of Great Britain, which is itself but a somewhat attenuated extension of the general Palæarctic insect fauna of continental Europe, presenting few, if any, features peculiar to itself, may, as regards its distribution, be arranged in three groups.

Firstly, there are those species, few in number and restricted in habitat, which are usually regarded as representing the survivals of the first post-glacial population of these islands, a group now limited in its occurrence to areas of considerable elevation, and to districts of the extreme north and west.

The second group comprises the great bulk of our fauna, species whose immigration here is supposed to have taken place long subsequently to the general establishment of the first group, and whose advent was only rendered possible by the secular amelioration of climate then proceeding.

This group, in its present distribution, may be conveniently considered under two heads.

(*a*) Such species, now universally and indiscriminately distributed over the country, as have been able to adapt themselves to those altered conditions of the environment which the general cultivation of the land during the last five centuries has imposed, and are, therefore nearly everywhere abundant.

(*b*) Such species, as wanting a similar capability of adaptation, are rigorously restricted in their distribution by conditions of habitat, flora, or geological formation; and it is obvious that the increase of area of land under cultivation, and a high standard of agriculture must be felt especially by members of this group, whose range is being continually lessened, and many of whose members are now probably in process of extermination.

Thirdly, there are a few species which may be perhaps regarded as the most recent immigrants from the Continent, whose range is, and probably always has been, strictly limited to districts of the South and South-East, who maintain even there only a precarious and erratic tenure, and in some cases would probably become extinct altogether, unless recruited by occasional continental immigration.

The Liverpool District.

For the purposes of a consideration of faunistic distribution, it is convenient to define the Liverpool district as that plain of Lancashire and Cheshire which extends from the valley of the Ribble on the North, to that of the Dee in the South, bounded on the West by the sea, and which does not extend beyond the outcrop of Permian and Carboniferous formations in the uplands of the East.

The area thus determined is singularly uniform in character, none of its elevations exceed 500 feet, and the formation of the entire district is that of the sandstones of the Trias, covered generally by the boulder clay.

The Distribution of the Insect Fauna of the Liverpool District.

Considering the three groups previously enumerated as comprising the whole of the British Insect Fauna, the third obviously has no place in our district, and the first, as we exclude North Lancashire, the high

moorlands of East Lancashire, or any part of Wales, is also unrepresented.

Our local fauna, then, is almost exclusively of the second group, and its principal interest lies in the occurrence within its limits of what has been indicated as the division B of that group, species existing sporadically over the whole country, but strigently restricted by conditions of environment. This leads to a consideration of those special features of the district which neither agriculture nor the spread of towns and manufactures have done anything to alter or impair. In a region like this, so devoted in Cheshire to a comprehensive agriculture, and in Lancashire to coal mining and multiform manufacturing industries, with a particularly dense population, it could hardly be expected that such features should be either numerous or extensive.

The following occur as perhaps, from a faunistic point of view, the most important of them.

(1) The belt of sandhills which lines the whole of the coast, extending from the Ribble to the Dee, and broken only by the estuary of the Mersey and the extension northward of the City of Liverpool. This belt varies in width, attaining a maximum of nearly two miles at Formby Point. Although its lateral movements have doubtless been, even in the historic period, extensive, yet it is of high antiquity, and of singularly persistent characteristics; and for these reasons maintains, perhaps, the most specialised insect fauna of the district.

(2) Large areas of peat bogs or mosses in the south of Lancashire, and north of Cheshire. These, however, have been within the last century very must curtailed, and are probably doomed to complete drainage and disappearance in the near future. An interesting fauna is maintained on these mosses, more extensive if not so specialised as that of the sandhills. In Cheshire, a large area of moss has within the century been drained and afforested, and in Delamere Forest

presents our only tract of extensive woodland. As might be expected, such a district has faunistic features peculiar to itself.

(3) The range of low sandstone hills which line the Dee shore of the Wirral Peninsula, and in the Overton and Peckforton Hills are continued across the Cheshire plain. These eminences are clad with heather and detached pine woods; which are but the last remnant of an extensive range of moor and woodland, and a few special forms still linger there not to be met with elsewhere in the district.

(4) There remains only to mention the great marshes of the upper Mersey from Ince to Frodsham, which possess certain limited faunistic features of their own.

With these exceptions the district under survey calls for no special comment, and only maintains an insect population such as is common to the whole of the north-western regions of England.

Considering the special Entomological fauna of the various localities mentioned above, it will be convenient to take the Class Insecta by its orders *seriatim*.

The Coleoptera (Beetles) then demand attention first. The number of this order at present known to inhabit Great Britain and Ireland is about 3,300 and of these 1,506 have been recorded in our district, or about 45% of the whole. We have more than half of the predacious beetles of the land and water, but the proportion is much reduced in the phytophagous groups, more especially in the wood-frequenting group Longicornia.

Longicornia.—An admirable list for Lancashire and Cheshire was published in 1908 by the Lancashire and Cheshire Entomological Society, and a list of additions appeared in their Annual Report for the session of 1912.

The limits of this publication prevent other than a very brief allusion to the more interesting of these local species, and perhaps it may be the most convenient

course to consider them in relation to the localities previously indicated.

(1) One of the most conspicuous beetles of the sandhill belt is *Cicindela hybrida*, which, although extremely erratic in its appearance, in some years occurs in the utmost profusion. Our most celebrated sandhill beetle, however, is *Ægialia rufa*, for which species the Birkdale and Wallasey coasts are the only known British localities. The genus *Aphodius* is well represented on the sandhills, more than half of the entire number known as British occurring there. Most noteworthy are *Ammoecius brevis*, only known as British from the Southport district, and *Heptaulacus villosus*, exceedingly scarce as British, one specimen of which occurred in the same locality and one at Wallasey. Among the Weevils, the rare *Apion annulipes* was captured by Dr. Ellis, of Liverpool, also at Wallasey, and the following are only a portion of a list of species more or less frequent among the sandhills, but rare or unknown elsewhere in the district: — *Hydnobius punctatissimus*, *Anisotoma dubia*, *Saprinus quadristriatus*, *Saprinus æneus*, *Sarrotrium clavicorne*, *Aphodius plagiatus*, *A. inquinatus*, *A. nitidulus*, *A. porcus*, *Georyssus pygmæus*, *Psammobius sulcicollis*, *Anomala frischii*, *Lacon murinus*, *Cryptocephalus aureolus*, *Helops palliatus*, *Anthicus bimaculatus*, *Sitones griseus*, *Hypera plantaginis*, and *Grypidium equiseti*.

On the foreshore itself there also occur a few special species. *Bledius arenarius* is in the utmost profusion about Crosby, and forms its tunnels beneath the surface of the sand far below high water mark. Higher up, beneath the debris and carrion, we may find *Phytosus balticus*, *Homalium rugulipenne*, *Aleochara obscurella*, *Bembidium pallidipenne*, *Broscus cephalotes*, *Dyschirius impunctipennis*, and *D. nitidus*.

(2) The coleopterous inhabitants of the mosses and of Delamere Forest, although less specialised, include some important species. The brilliant *Carabus nitens*

was formerly abundant on Chat Moss, and may yet be occasionally taken there. Also worthy of mention are *Anchomenus ericeti*, *Hydroporus tristis*, *H. incognitus*, *H. atriceps*, *Rhantus bistriatus*, *Hydaticus seminiger*, *Coccinella hieroglyphica*, *Elater balteatus*, *E. pomorum*, *Campylus linearis*, *Phlœotrya stephensi*, and *Pissodes notatus*.

The extensive woodlands of Delamere Forest, which we have associated with the mosses, contribute a very large number of special species to our district fauna. It must suffice to enumerate only a few of these, beetles which may be taken either in the decaying tree stumps, or beaten from the branches of the Oaks, Birches and Pines, of which the forest consists. Among the former are *Liodes humeralis*, *Hister succicola*, the majority of the *Rhizophagi*, *Epurœa obsoleta*, *Ips quadripunctata*, *Pityophagus ferrugineus*, *Scolytus intricatus*, *Pityogenes bidentatus*, and *Trypodendron domesticum*; while the latter include *Athous niger*, *Silpha quadripunctata*, *Podabrus alpinus*, *Leiopus nebulosus*, *Attelabus curculionoides*, *Deporus betulœ*, *Balaninus villosus*, and *Brachytarsus varius*.

(3) The upland reaches of heather, from Bidston round the Wirral coast to Burton, are the haunts of a few forms of interest, of which the following are the most noteworthy:—*Cymindis vaporariorum*, *Bembidium nigricorne*, *Dromius nigriventris*, *Geotrupes typhœus*, *Chilocorus renipustulatus*, *Phlœophthorus rhododactylus*, and *Ceuthorrhynchus ericæ*.

(4) There remains only to mention the fenland of the Upper Mersey. Here, by the side of the broad ditches, *Stenolophus vespertinus* may be swept from the long grass. In this locality also occur *Bagous alismatis*, *Hedobia imperialis*, *Pterostichus minor*, *Brychius elevatus*, *Platambus maculatus*, *Gyrinus distinctus*, and several species of *Donacia*, not occurring elsewhere in the district, one, *Donacia nigra*, being a rare species everywhere.

NEUROPTERA.—This order includes the Dragon Flies, Stone Flies, and Lace-wing Flies. The members of the order are not numerous in this country, and the *Odonata* (Dragon Flies) is the only group to which much attention has been given locally, Mr. J. Arkle, of Chester, having made them a special study.

There are 45 reputed British species (eight of these, however, are doubtful as British). The species recorded from our district amount to 16.

(1) As the presence of water is a necessity in the ontogeny of these insects, the larvæ of all of them being aquatic, as might have been expected we find them absent from the dry sandhill zone.

(2) On the mosses the following occur:—*Leptetrum quadrimaculata*, *Leucorrhinia dubia* (an exceedingly rare species, and the most noteworthy in the local fauna); *Sympetrum vulgatum*, *S. Scoticum*, *Æschna junca*, *A. cyanea*, *Lestes sponsa*, and *Pyrrhosoma minimum*.

(3) On the upland heaths *Orthetrum cœrulescens*.

(4) And in the river marshes, among others, *Calopteryx splendens* has been taken.

HYMENOPTERA.—This order includes a very large number of insects. It embraces the Ants, Bees, Wasps, Ichneumon Flies, Gall and Saw Flies.

The only groups which have been at all locally studied, are the first three of these, the Ants, Bees and Wasps usually classed together as the *Aculeate Hymenoptera*. A list of the occurrence of these insects in Lancashire and Cheshire, has been published by Mr. Willoughby Gardner, F.R.G.S., F.L.S., incorporated in which are the records of Miss E. C. Tomlin and Mr. R. Newstead (Chester), and Mr. J. T. Green (Birkenhead).

(1) Peculiar to the sandhill zone are several rare Bees and Wasps, and even one species not known elsewhere in Great Britain. This latter insect is the

Bee *Colletes cunicularia*, first taken at Wallasey on May 4th, 1855, by the Rev. H. H. Higgins, and usually abundant there. It has also occurred at Waterloo, Crosby, Blackpool, Rock Ferry and Chester.

The other noteworthy sandhill species are *Astata stigma*, *Oxybelus mucronatus and Cœlioxys acuminata.*

The late Mr. Benjamin Cooke collected near Manchester, and records many species. Among these are the Ants, *Ponera contracta* and *Myrmica lobicornis*, the Wasp, *Odynerus sinuatus*, the Bees, *Andrena angustior*, and more especially *Halictus atricornis*; the latter, a species then new to science, was discovered by Mr. Cooke, at Hazelgrove, near Manchester, in July, 1866 (see Entomologists' Annual, 1870, p. 26) It has since been taken at Stretford, and near Clitheroe.

On Chat Moss *Bombus lapponicus* occurs.

The rare Mason-bee, *Osmia xanthomelana*, was taken in abundance near Liverpool, by Mr. G. Waterhouse, in 1835, but the precise locality is not recorded.

The remaining species are distributed with general uniformity over the district, their occurrence being regulated more by suitable spots for nidification, or by the presence of special flowers—or, in the cases of the parasitic species, by that of other Bees, their hosts—than limited to particular areas.

The Aculeate Hymenoptera form but a very small portion of the entire order, perhaps the most interesting one of the Insecta.

Lepidoptera.—The Lepidoptera (Butterflies and Moths), a large and certainly the best known of the orders of Insecta, has been far more minutely and exhaustively recorded, as regards local occurrence and distribution, than any other, and has enlisted for its study more observers than all the rest put together.

The present British List enumerates 2,095 species, and of these about 1,160 have been recorded from the district under consideration; the inclusion, however, of Lancashire *north* of the Ribble would have increased

the total by about 200 species, principally micro-lepidoptera, a group which has been specially studied by Messrs. Hodgkinson and Threlfall, of Preston.

Of the Rhopalocera (Butterflies) we have records of 35 species, the total for Great Britain being 66, but not more than 20 of these 35 are in any sense common. There are some 18 recorded captures of that rare species *Vanessa antiopa*, and one of *Lampides bœtica* (Coll. Grosvenor Museum, Chester). The variety *rothliebii* of *Cœnonympha typhon* occurs on all mosses, but it now scarce in South Lancashire and Cheshire.

Of the Heterocera (Moths), (2,029 British species), about 1,125 have been recorded. This, a much larger proportion of the whole than in any other order, we may regard as testifying more to a larger number of observers than to a necessarily greater local representation of species.

(1) Perhaps one of our most interesting sandhill species is the Hawk moth, *Deilephila galii*. This beautiful but erratic insect has been locally abundant on four occasions, the years 1834, 1859, 1870, and 1888, but since the last year only occasional examples have been found. Owing to the popularity of golf the area available for this and other sandhill species has been sadly restricted, and local insects, once abundant, are now quite scarce.

Among other interesting and otherwise rare sandhill species may be mentioned *Lasiocampa trifolii*, *Leucania littoralis*, *Tœniocampa opima*, *Agrotis præcox*, *Eubolia lineolata*, *Botys* (*Rhodaria*) *sanguinalis*, and *Biston* (*Nyssia*) *zonaria*. This last moth is peculiarly interesting, as having first been added to the British list from specimens taken on Wallasey sandhills, by the late Mr. N. Cooke, of Liscard, in 1833; it is now scarce in Wallasey, very few having been found in the last ten years. Since the last report we are able to record *Luperina guenéei* at St. Annes and Southport, a species only previously known to Britain by three specimens.

(2) The Lancashire and Cheshire mosses are localities which have been worked with singular persistence and completeness by the many Lepidopterists of the Lancashire towns. Their list of specialities is a copious and interesting one, but too long to quote in anything like its entirety.

The following species may, however, be mentioned:—*Setina mesomella*, *Lithosia sericea*, *Nemeophila russula*, *N. plantaginis*, *Asphalia flavicornis*, *Acronycta menyanthidis*, *Hadena* (*Celæna*) *haworthii*, *Anaitis paludata*=(*Carsia imbutata*), and *Acidalia circellata*, the last erroneously surmised to be extinct, but still of extreme rarity.

(3) The Lepidopterous fauna of the heather-covered hills and of the Mersey marshes is not very extensive, and there are no species so far discovered peculiar to those regions.

The former comprise *Hipparchia semele*, *Polyommatus ægon* (now extinct), *Saturnia carpini*, *Hemaris bombyliformis* (formerly), and *Agrotis porphyrea*.

(4) While among the latter may be mentioned *Plusia festucæ* and *Gortyna flavago*.

If space permitted one could write a good deal upon the occurrence of melanism in the Lepidoptera of Lancashire and Cheshire; the black variations of *Triphæna nebulosa* which are practically confined to Delamere Forest; the variety *melanocephala* of *Acronycta leporina*, peculiar to North Cheshire and South-West Lancashire; and the black variety *steinertii* of *Acronycta alni*, only hitherto recorded from the same area in Britain, as well as others. The warehouse pests in Liverpool are of great economic importance and equally interesting; in 1921 a species new to Britain was found, viz., *Auximobasis normalis*, and in 1922 *Corcyra cephalonica* did great damage to ground nuts stored in Liverpool. The Mediterranean flour moth, *Ephestia kuhniella*, is well established, also *Tinea granella* and *Sitotroga cerealella*, both of which seriously damage stored grain. In North Lancashire

Blastobasis lignea was discovered in 1918 as new to Britain; its food is not known at present, but that it is of economic importance is undoubted. First detected by Mr. Albert E. Wright, of Grange-over-Sands, it introduced a new family, as well as a new species, to Britain, an event unprecedented within living memory.

*Hemiptera Heteroptera. Of this order, the majority of whose numbers are known *par excellence* as "bugs," but which also includes the aquatic water boatmen and water scorpions.

Of this group about 200 have been so far recorded in our district, but as little attention has been devoted locally to the order, and as few observers have recorded the capture of any species at all, it is probable that many more occur.

Very few appear to be attached to special localities, and the bulk of such as occur are to be taken by general sweeping of herbage or beaten from various trees.

(1) It is still, however, possible, to mention a few forms in connection with the sandhills, and of these the principal are *Therapha hyoscyami*, *Peritrechus luinger*, *Plesiocoris rugicollis*, *Orthocephalus saltator*, and *Macrotylus paykulii*.

(2) In Delamere Forest occur a long list of species. Among others may be mentioned *Tropicoris rufipes*, *Acanthosoma* (all the British species except *tristriatum* on birch), *Geris argentata*, *Caloceris sex-guttatus*, *Cylloceris histrionicus*, and *Corixa limitata*.

(3) Among the heather at Heswall and Helsby *Ischnorhynchus geminatus* is often abundant in July.

And the marshes (4) yield most of the species of *Geris*, and *Corixa*.

Hemiptera Homoptera.—This order is divided into the sub-orders *Cicadidæ* (Cicads and Froghoppers),

* A few interesting records of local species are given in a recent paper by Mr. H. Britten, (Lanc. and Ches. Nat., 1920).

Psyllidæ, *Aphidæ*, *Aleuroididæ*, and *Coccidæ* (scale insects).

A fair local collection of these insects exists in the Chester museum, but as the species are unidentified, no report on the group can be made.

In *Psyllidæ*, an obscure group of minute flies, less than 50 species are catalogued as British; locally they have been almost entirely neglected.

Among the *Aphidæ* (Aphides) the only local forms worth mention are *Paracletus cimiceformis*, a large apterous aphis found in Ants' nests in Delamere Forest and elsewhere. *Melanoxanthus salicis*, and the curious gall-making Aphis of the spruce, quite a pest in Delamere Forest, *Adelges abietis*.

The *Aleuroididæ* is another small and little known group, the only species noticed in the district being *Aleurodes brassicæ*.

The *Coccidæ*, or scale insects, are undoubtedly by far the most important group of the Homoptera. They alone, of the whole of the Insecta (if we except the Bees), furnish, in Cochineal and in various kinds of Lac, a not unimportant article of commerce.

The total number of species discovered up to the present in Britain is about 120, but a considerable proportion of these, as they only occur on plants under glass, cannot be considered as indigenous.

Locally, the group has been most exhaustively studied by Prof. R. Newstead, who has described many British species new to science, and has also published in the 'Mononograph of the Coccidæ of the British Isles' (Roy. Society, Vols. 1 and 2, 1900, 1902) an account of all the then known species.

Diptera.—The last order of the Insecta to mention is the Diptera (two-winged flies). This extensive group is probably less well known than any other of the larger orders. It is doubtful whether anything like a reliable list of the British species has been compiled, but comparatively little is known of their local distribution.

Of one family, the *Syrphidæ*, the late Rev. H H. Higgins published a local list, and enumerated 62 of the 153 then (1858) recorded British species.

One species, *Chrysotoxum intermedius*, seems only to have been taken in the sandhills, and the mosses contributed 2 others, *Chrysotoxum bicinctum*, and *Doros citrofasiatus*, the rest were generally distributed.

The district has furnished one Dipteron new to science, *Homalonyia vesparea*, taken by Prof. Newstead in a nest of the wasp *Vespa germanica*, near Chester. In the same situation the rare species *Acanthiptera inanis* was also discovered.

Owing to the important part played by mosquitos in the transmission of malaria, considerable attention has been given to the study of these insects in the British Isles by members of the staff of the Liverpool School of Tropical Medicine. All three of the British species of *Anopheles* have been found breeding in the immediate neighbourhood of Liverpool, viz., *Anopheles bifurcatus*, *A. maculipennis* and *A. plumbeus*. Of the Culicine mosquitos, *Theobaldia annulata*, *Culex pipiens* and *Finlaya geniculata* are common and widely distributed. As aliens, *Stegomyia fasciata* and *Culex fatigans* have been taken on board ship in the Port of Liverpool.

Aphaniptera (Fleas).—In 1920-21 an investigation was carried out by the Entomological Staff of the Liverpool School of Tropical Medicine, in conjunction with Professor W. E. Hope, Medical Officer of Health, and his assistant, Mr. W. Hanna, to determine the distribution of the various species of fleas occurring on the rats in the Port and City of Liverpool, with special reference to those species which are responsible for the transmission of plague from rat to rat and from rat to man.

Five species of fleas were found to occur on rats from the ships, Port, and City of Liverpool. They were:—*Zenopsylla cheopis*, *Ceratophyllus fasciatus*,

C. londiniensis, *Leptopsylla musculi*, and *Ctenocephalus canis*.

The 'plague flea' (*Xenopsylla cheopis*) occurred freely on ship rats throughout the whole period of investigation. It was also found on three rats from the dock sheds, *and a permanent breeding place of the species was discovered in certain premises in the City*

Ceratophyllus fasciatus was universally prevalent during the whole course of the investigation. The number of fleas per rat was greatest during the summer months, but the curve of frequency could not be correlated in detail with that of the average temperature.

(2) With these exceptions, hardly any systematic study of the order, as it occurs in this district, has been made. There are small local collections in the museums of Liverpool and Chester, but the identification of species is imperfectly reliable.

Orthoptera (Earwigs, Cockroaches, Crickets and Grasshoppers).—In his British Orthoptera (Ray Society) Lucas records the occurrence of a colony of the 'domestic' earwig, *Anisolabis annulipes* in Cheshire, and also the capture (by Sopp) of six species of 'casual cockroaches' in the Liverpool Docks. The records of the occurrences of the other members of this order are not sufficiently copious for publication.

THE VERTEBRATE FAUNA OF THE LIVERPOOL DISTRICT.

T. A. Coward, M.Sc., F.Z.S.

Faunal areas, unless well defined by physical features, are very artificial, and the Liverpool district has no natural boundary to the east and south. For the purpose of ascertaining the fauna of the immediate neighbourhood, Liverpool may be taken as the centre of a natural area lying between the estuaries of the Ribble and Dee, and if a circular sweep be taken, with Liverpool-Southport as the radius, the following towns or their outskirts will be included within the semi-circle:—Ormskirk, St. Helens, Wigan, Warrington, and Widnes in Lancashire; Frodsham, Chester, Birkenhead and other Wirral towns, in Cheshire. Although much of this area is urban there are within it many well-wooded tracts, several low hills, a long belt of sand-dunes, many acres of marsh, and much arable land.

The inclusion of these rural districts explains, to a great extent, the richness of the fauna, which, with the exception of certain hill forms, is very similar to that prevailing in Cheshire and in Lancashire south of the sands.

Forty-six mammals have occurred in Cheshire, but the three Ungulates, all now emparked, should be excluded. The Harp Seal and the Bottle-nosed Dolphin swell the Lancashire list to 48, but it must be remembered that Lancashire mammals have never been satisfactorily worked. At least 36 of the 48 occur within the Liverpool area, and one will be added in due time, the alien Grey Squirrel, which is rapidly spreading over Cheshire. Five bats certainly occur, and Leisler's Bat and Natterer's have been taken so

ear this artificial boundary that their presence is robable. Two others are said to have been taken—he Barbastelle and Lesser Horse-shoe—but confirmation is desirable. The last is common on the Denbigh imestone. There is no evidence to support the eported occurrence of the Serotine. All five insectivores, and six terrestrial Carnivores are found, nd formerly the Polecat could be added, but is now extinct.

The Badger is not uncommon in Delamere, and has been captured recently near Wigan; the Otter still aunts the Cheshire streams, and in 1922 one was killed at Blundellsands. Perhaps the last Polecat was one killed at Burton in Wirral in 1840, but the Pine Marten, evidently a wanderer from Wales, was trapped near Chester in 1891.

The coasts of Lancashire and Cheshire are hardly suitable for seals, but both the Common and Grey appear occasionally. The Grey undoubtedly is the commoner of the two, and probably many breed on the wilder Welsh coasts, for a young one was captured at Hoylake in 1909. A large adult example was killed in the Canada Dock in 1861, and a still finer one, now in the Warrington Museum, was done to death in the canal above that town in 1908. In 1873 a Hooded Seal was taken on Frodsham Marsh. The Harp Seal, often stated to have been caught in the Mersey in 1874, was really killed at Arnside, far to the north of the district, in 1868.

At least 11 Rodents may be safely included, and it is possible that the Dormouse might be added; it is common on the Welsh side of the Dee. The Harvest Mouse has been found at Frodsham, Appleton, Delamere and Ormskirk, but whether it is indigenous or not cannot be proved; it is easily introduced from the south in produce. Three forms of the Black Rat occur too frequently in the docks at Liverpool, Birkenhead and Runcorn.

The Irish Sea is not on the ordinary migration route of any Cetacean, unless it be the Porpoise, but the

Bottle-nosed Whale, *Hyperöodon rostratus* (Müller), has frequently strayed into Liverpool Bay and the estuaries, where in the shallow water over the banks it has got into trouble. Pennant first recorded the species for the Dee in 1785, and since then at least ten have been stranded in the Mersey and Dee or on the Hoyle Banks. The last that I have a note of was dragged ashore at Flint in 1912. The Rorquals appear to avoid the Irish Sea, but in 1863 a Hump-backed Whale, *Megaptera böops* (Fabr.), over 31 feet long, was stranded in the Mersey at Speke. A Killer, *Orca orca* (Linn.), came ashore at West Kirby in 1876; the Dolphin, *Delphinus delphis* Linn., has occurred more than once, and a White-beaked Dolphin, *Lagenorhynchus albirostris* Gray, was stranded at Hilbre in 1862.

Despite the residential character of much of the coastal land there are considerable stretches where avian residents abound, and inland the security afforded by large gardens, and open spaces or parks provided by Municipal or private enterprise has prevented serious depletion of the avifauna. Moreover, the coast and some inland localities are especially rich in passage migrants and winter visitors, the majority being waders and ducks.

The Lancashire list contains some 260 species of birds, and that of Cheshire perhaps 235, but it is impossible to give exact numbers, as many of the records of rare species cannot now be verified. The Liverpool list, for the area specified, numbers about 230, and between 160 and 164 have occurred so frequently that they may reasonably be considered regular in their visits.

Nine crows are included, but two are merely casual wanderers; the Raven has been seen and killed occasionally; perhaps the last was one that was shot near Southport in 1914; and the Chough, a wanderer no doubt from the Isle of Man, where it nests, has reached the shores of the Bay. The Hooded Crow also nests in Man and occasionally visits the shores

and estuaries, but it is far less frequent than the Carrion, which nests in Wales and Cheshire. The Nutcracker has been killed at Vale Royal, just beyond the artificial radius. Persecution has failed to banish the Jay and Magpie.

The Starling is increasing, and in the colder months congregates nightly in some immense roosts. The Rose-coloured Pastor and the Golden Oriole are exceptional wanderers to the district or to the country just beyond its borders.

Finches and Buntings number 22. The Hawfinch is a commoner resident than is usually suspected, but the Goldfinch has vanished as a nesting species; clean farming and bird-catching have been against it. The Siskin, as a winter visitor, is irregular in appearance; the Twite is another occasional winter visitor in flocks, and a nest of this moorland species was discovered not far from Liverpool in 1916. The sporadic Crossbill has sound claim to be included, for not only does it occur occasionally on migration—as when in 1911 one struck a Heswall window—but after the last big invasion birds nested at Formby and Delamere. Snow Buntings frequently haunt the tide line in winter, finding food at high-water mark, as do Linnets, Larks and other birds.

The Nuthatch, a very local bird in the North, occurs at Chester. The Goldcrest abounds, now that it has recovered after the depletion in numbers during the spring of 1917, but the records of the Firecrest require confirmation. Five Tits certainly occur, and it is likely that the Willow Tit, *Parus borealis kleinschmidti* Hellm., should be included, as it nests a little further east.

There is evidence that the Woodlark occurred at any rate occasionally, but it has not been noticed for very many years; the Shore Lark, though much rarer than on the East Coast, has been noted at Hilbre, Formby, Birkdale and Southport, the last in 1920. The White Wagtail is a regular bird of passage, both along the coast and inland, and it is probable that the Blue-headed Wagtail, *Motacilla flava* Linn., occurs with

passing Yellows, as it has been shot in Delamere Forest and seen in North Wales. Three Pipits are resident, but the Rock Pipit, owing to the nature of the coast, only in one locality. Richard's Pipit, *Anthus richardi* Vieill., has been recorded at Crosby, but should be accepted with reserve.

The Tree Creeper nests; I have seen the bird in Birkenhead Park. There are several records of the Great Grey Shrike, and the Red-backed Shrike has nested in Wirral, and has been noted recently at Bidston. In 1913 the Waxwing was seen at Oxton, and there are many older records for the Liverpool area.

Many of the Warblers are abundant. Both Whitethroats, the Black-Cap, Garden Warbler, Grasshopper, and Reed Warbler occur in suitable places, and the Sedge Warbler is exceedingly common in the low-lying marshy country. All three "Leaf Warblers" occur, but the Chiffchaff is more plentiful in Cheshire than in Lancashire.

The occasional nesting of the Ring Ousel on the Frodsham hills is interesting, as this moorland species is only known elsewhere in the district on passage. The recorded occurrence of the Siberian Thrush has never been substantiated. The Black Redstart is a passage migrant, more frequent in its visits than is generally supposed; the Nightingale, too, has been noted, once at any rate. The evidence given by John Price, in his "Remains," supports the identity of the much-doubted Birkenhead Nightingale of 1883, and the bird has certainly reached the country but little south of Chester in several springs. Stonechat, Whinchat and Wheatear are regular, the first nesting close to Birkenhead, the Wheatear on the sandhills. The Greenland Wheatear, like the White Wagtail, is a regular West Coast bird of double passage. The Pied Flycatcher is often seen in spring on its way north.

All three Woodpeckers nest in the area, though not in large numbers, but the Wryneck, which was reported

as nesting many years ago at Saughall Massey, and which certainly did nest at Oakmere in 1884, can now only be counted as a very rare visitor on migration. The abundance of Meadow Pipits on the dunes, and Tree Pipits in the Cheshire woods attracts the Cuckoo; the Swift is an increasing species, the Nightjar churrs within a few miles of the City, and the Kingfisher still finds safe nesting holes inland, and catches crustaceans and small fish in the tidal gutters in winter. Obituary notices of the Hoopoe are too numerous.

Of the five Owls that are in the list, the Short-eared pays occasional visits to the dunes and to Wirral, and the Little Owl, steadily spreading from the Midlands, has established itself in the district within the last two or three years. Amongst the diurnal raptorial birds, some 12 in all, the Marsh and Hen Harriers have both been seen and shot, and Buzzards, both Common and Rough-legged, pass on migration, but they are often slowly circling round at so great an altitude that it is difficult to be certain of the species. The White-tailed Eagle, now alas! only a bird of passage in the British Isles, has been shot at Leasowe and near Chester.

The Honey Buzzard is recorded from Burton (1841), and the Kite has been killed once and seen on other occasions within the district, near Chester and in Delamere Forest. The Peregrine regularly frequents the shores and marshes, harrying the waders and lesser wild-fowl.

The Cormorant is commoner off shore than the Shag, though the latter occurs, and the Gannet is a not infrequent wanderer to Liverpool Bay.

Although Geese may be seen on the shore occasionally, the favoured haunts are the banks and marshes of the Dee and Mersey Estuaries, where the Pink-footed and White-footed Geese feed in large gaggles. The Bean and Grey-Lag are rare, but have been obtained. Apparently the Barnacle was formerly abundant, but now has deserted its old haunts, though I saw one at West Kirby at close quarters in February, 1923. The Brent is not plentiful, but small skeins may

be seen passing off-shore, especially at the mouth of the Dee. Herds of both Whooper and Berwick's Swans appear from time to time in winter, and not infrequently leave one or more of their number behind when they depart. The Sheld-duck abounds in the estuaries and on the dunes, and a number now find suitable nesting holes at some distance from the shore. The Ruddy Sheld-duck was killed in the Mersey in 1892, a year when there was a recognised invasion.

Eight Surface-feeding Ducks are known, and some, like the Wigeon and Teal, are exceedingly plentiful, but the Gadwall and Garganey have not often been obtained. The Pintail is an abundant winter visitor to the Dee, and the Mallard, Teal and Shoveler nest within the area. The Tufted Duck is the only resident Diving Duck, but the Pochard and Goldeneye are plentiful on inland pools and the Scaup on salt water. The Long-tailed Duck is an occasional visitor. The Eider is very rare, but has been seen diving just outside the Leasowe Embankment. The Scoter is exceedingly abundant in Liverpool Bay; large numbers may be seen even so early as July. The Velvet Scoter also occurs, but is by no means common. The Goosander is the commonest 'sawbill' inland, the Red-breasted Merganser in the estuaries, and the Smew is occasional, even so far up the river as Chester, and inland on the Delamere pools.

There are one or two Heronries within easy distance for a Heron, and the bird occurs close to Liverpool; the Bittern still ventures on migration, and one was killed recently near Wigan. In 1893 a Little Bittern was shot at Wallasey. The Dee fowlers call the Shoveler the 'Spoonbill,' the genuine bird is to them the 'White Spoonbill'; it has been killed on the Dee at least twice, the last in 1913, and in 1922 one was shot at Formby. There are two old records of the Glossy Ibis. The Collared Pratincole has been killed at Ormskirk, the Stone Curley near Chester, and both Grey and Red-necked Phalarope on the Dee and in Cheshire; the Great Snipe is recorded.

The Knot is a very abundant wader along the shore, some of the flocks numbering many thousands of birds; flocks frequent the Dee, but the bird is far more plentiful along the Lancashire shore at Ainsdale and Freshfield. Numerous Sanderlings, Dunlins, Redshanks, and Bartailed Godwits occur with the Knots or in distinct hordes. The Greenshank, Curlew Sandpiper, Little Stint, Ruff and Black-tailed Godwit may often be seen with the other birds. Turnstones and Purple Sandpipers occur where there are sandstone outcrops, and hunt the weed at high-water mark for crustaceans. The Spotted Redshank was recorded by Brockholes, but the records of the Spotted Sandpiper are not entirely satisfactory.

The Common Sandpiper is met with on the shore, but is more regular on the inland streams, where it nests; the Green Sandpiper is a regular bird of passage and winter visitor.

Yarrell records a Buff-breasted Sandpiper, *Tryngites subruficollis* Vieillot, killed at Formby in 1829, and Mitchell a Red-breasted Snipe, *Macrorhamphus griseus* (Gmelin), said to have been killed at Southport.

Curlew and Whimbrel frequent the flats in large numbers, and the packs of Oystercatchers, a bird which nests locally, are often very large. In Wirral and elsewhere the Golden Plover is an abundant winter visitor, and the Grey Plovers is common along the shore. A few pairs of Ringed Plovers manage to rear their young, but their numbers are greatly augmented at the season of passage. On passage, too, trips of Dotterel appear with frequency.

The Herring Gull is the most abundant gull on the coast, but the Blackhead is very plentiful; there are now at least four nesting colonies of the smaller bird within the area. Common, Greater and Lesser Blackbacks are abundant visitors at all times except in the height of the nesting season, and both the Glaucous and Iceland Gulls have been noted; the Little Gull has been seen on several occasions. The Kittiwake occurs,

but is neither common on the shore nor in the Bay.

Common, Arctic and Lesser Terns still manage to nest where they get protection, and the Roseate and Sandwich Terns are visitors; the Black Tern is not infrequent as a passing visitor to the meres and marshes. The Great Skua has been noticed on the shore, as also Buffon's and the Pomatorhine, but the Arctic is the most frequent visitor to the coast line.

The washed-up bodies of Puffins, Guillemots and Razorbills are too common on the tide-line, for nowadays many of these birds are badly oil-clogged; they are less frequently seen in good health on inshore waters. Leach's Petrel is rather commoner than the Storm as a gale-driven wanderer, but both occur from time to time; the Manx Shearwater is regular as a frequenter of the Bay, feeding there during the daytime. The Fulmar has occasionally wandered to the area. The only European example of the Kermadec Petrel, *Pterodroma neglecta* (Schlegel) was picked up just to the south of the radius we have taken in 1908. Three Divers and five Grebes are included in the list, the Great Crested Grebe and Dabchick as nesting species.

Water Rail, Spotted Crake and Corncrake occur, and the Moorhen and Coot abound. The Stock Dove haunts the dunes, and within recent years the Turtle Dove has settled down as a summer resident. In the two large invasions of the Sand-Grouse birds were obtained in the district, and in the later incursion, that of 1888-89, there was some hope that the survivors would breed, but neither eggs nor young were discovered. Amongst the Game Birds the Quail is irregular, and the Black Grouse, which used to nest in Delamere, is now extinct, in spite of an effort made to reinstate it. A Red Grouse, as a wanderer, has been killed occasionally in Wirral.

Of the 11 Reptiles and Batrachians that occur two deserve special notice, the Sand Lizard and Natterjack,

for their normal ranges are far removed from the somewhat restricted areas which they frequent on the Lancashire and Cheshire coastlines; the Sand Lizard has not been noticed in Cheshire for many years, but is still plentiful on the Lancashire dunes.

THE CLIMATE OF LIVERPOOL.

W. E. Plummer, F.R.A.S.,
Astronomer to the Mersey Docks and Harbour Board.

The factors of climate cannot be expected to show any material change in the 27 years that have elapsed since the British Association last met in Liverpool. This constancy of average conditions lends weight to the suggestion that a class of observations, whose principal service is to prove that past meteorological events will repeat themselves, might be abandoned without serious loss. On the other hand, it may be, and is, argued, that the knowledge of the weather conditions experienced over a number of years is of great public utility, whose value increases with the length of time over which the observations are spread. Further, those observations form the foundation on which dynamic meteorology must be built, and by which the deductions from theory must be tested. In aviation, in agriculture, in insurance against loss, the information drawn from statistics is of some service to those who trust the indications, and we know of no other way of increasing the value and trustworthiness of forecasts than by pursuing the routine hitherto followed. To abandon a method which is not without promise, when no adequate substitute presents itself, seems a very doubtful policy.

In compiling the few facts given in the 1896 Handbook some fifty years' results were utilised. Now the time is extended to cover nearly 80 years, and the slight variations from the earlier figures may seem a very poor return for the labour of collection and discussion of the added material. Those who are disposed to

adopt this view and would wish that the scope should be widened, may learn with satisfaction that steps have been taken to embrace a larger area in the enquiry and to increase the interest by tracing the variation of these figures with increasing distance from the centre. Under the guidance of Prof. Roxby, with the assistance of Miss Winchester, statistics have been collected to determine how far topographical conditions and varied environment affect the records of precipitation and temperature. Such investigations can have important results, and in no direction are they likely to be of greater use than in providing a means for testing and improving the accuracy of general forecasts, which applied to wide areas represent the meteorological conditions with gratifying exactness, but the variations introduced by local circumstances are too many and minute to be considered by a distant forecaster, but which need to be treated judiciously to obtain satisfactory results. As examples of local influence, it may be mentioned that observations made at the mouth of the Mersey indicate the presence of a distinctly more northerly component in the wind current than is recorded at shore observations, a fact of great importance in eliminating the effect of wind on tidal observations. The unusual rainfall recorded at different stations in Liverpool will vary from 27·6 to 33 inches, the latter amount being measured on the East of the City, whence there is a steady decrease, till the Manchester district is approached. Some temperature variations are also well marked, the area between the Mersey and the Dee exhibiting higher readings than on the Eastern side. The object in giving these few facts, kindly supplied by Miss Winchester, is to show that the statistics here quoted are strictly applicable to only a very small area, and to indicate the necessity of maintaining well-distributed centres of observation.

In the 1896 Handbook the observations of temperature were divided into two periods, permitting the observations of Bidston to be contrasted with those made at the older Observatory, at the Waterloo Dock,

Liverpool. But the observations at Bidston have now been continuously pursued for a sufficient length of time (56 years) to give a trustworthy mean at one station, and the Liverpool observations are excluded. To show the small variation in mean temperature, the entire series has been divided into two series, each of 28 years. The date of division coincides very closely with that of the last visit of the British Association.

Month.	Mean Monthly Temperature 1866—1894.	Mean Monthly Temperature 1894—1922.	Difference : 1st period— 2nd period.	Mean Monthly Variation for Whole Series.	Mean Daily Amplitude
	°	°	°	°	°
January ...	39·10	39·57	— 0·47	1·96	8·3
February ...	40·81	40·33	+ 0·48	2·01	9·0
March ...	41·92	42·03	— 0·11	2·01	10·2
April ...	47·13	46·69	+ 0·44	1·96	12·4
May ...	51·90	52·31	— 0·41	1·69	12·9
June ...	57·78	57·48	+ 0·30	1·31	13·1
July ...	60·50	60·37	+ 0·13	2·14	12·9
August ...	60·19	59·88	+ 0·31	2·13	12·2
September	56·24	56·23	+ 0·01	1·35	11·0
October ...	49·26	49·63	— 0·37	2·09	9·2
November ...	43·51	43·83	— 0·32	2·51	8·4
December ...	39·67	40·69	— 1·02	2·70	7·9

The mean temperature for the whole year works out to 49·1 degree. And the table tends to confirm the generally received opinion, that the late autumn and winter months have been less cold during the last few years, while the spring has generally delayed its advent. The fifth column of the table shows the amount of temperature variation that may be expected to occur in the mean value of any month, and the last column the mean daily amplitude, or the mean of the daily variations of temperature in each month.

Narrowly connected with mean temperature is the quantity of sunshine and cloudiness of the sky observable each day. The character of the locality in which the observations are made greatly influences these climatic factors. The proximity of a large body of water supplies readily much moisture to the atmosphere by evaporation, and a busy centre of trade and shipping

produces the dust nuclei to form centres of moisture condensation. Liverpool is favoured by a large measure of sunshine, and in comparing the monthly duration with that recorded in other stations apparently more advantageously placed, it must not be overlooked that the position of Bidston is 200 feet above the port of Liverpool and remote from the great industry of the Docks. A comparison with the records of two neighbouring Observatories, that of Southport on one side and Stonyhurst on the other, may serve to show that though there is no method for calculating with any precision the effects of trade and manufacture in impregnating the atmosphere with smoke or dust particles, yet the effect of the observation is confined to very small limits, and that a very short removal from the origin of inconvenience quickly reduces the deleterious effects. Of the prevalence of clouds it is more difficult to speak with statistical accuracy. The differences between fog and mist on the one hand and cloud, properly so called, on the other, have not been long established and well recognised. The character of the observations that have been made does not indicate with certainty whether an increase in manufacture and transport has rendered the air less transparent. No apparatus has been used for measuring the area of the sky covered, and no long record has been preserved showing the distance at which terrestrial objects could be perceived. Moreover, different observers using different methods of estimation have contributed to the record. Most of the errors have probably counteracted each other in the long sequel, for if the total be divided into ancient and modern periods, as in the case of the temperature observations, very little difference is noticeable between the figures of the two periods.

The great difference between the duration of bright sunshine at Bidston and Southport is confined to the summer months, the sign of the difference is reversed in the winter season. The reason for this seasonal variation is not easily explained. The deficiency of

sunshine at Stonyhurst, situated on the eastern side of the County, is explained by the general humid character of the climate, the mean annual rainfall

DURATION OF SUNSHINE.

Month.	Average Duration of Bright Sunshine.			Difference Bidston—Southport.	Difference Bidston—Stonyhurst
	Bidston.	*Southport	Stonyhurst		
	hrs.	hrs.	hrs.	hrs.	hrs.
January...	54·3	43·8	32·4	+ 10·5	+ 21·9
February	68·5	68·3	58·1	+ 0·2	+ 10·4
March ...	100·7	118·2	102·3	— 17·5	— 1·6
April ...	165·2	169·4	147·9	— 4·2	+ 17·3
May ...	210·2	209·9	186·3	+ 0·3	+ 23·9
June ...	206·1	211·4	186·4	— 5·3	+ 19·7
July ...	187·4	205·4	172·7	— 18·0	+ 14·7
August ...	159·5	180·9	148·0	— 21·4	+ 11·5
September	131·2	139·4	124·0	— 8·2	+ 7·2
October ...	93·4	95·7	86·0	— 2·3	+ 7·4
November	63·3	54·7	46·2	+ 8·6	+ 17·1
December	43·6	35·6	25·7	+ 8·0	+ 17·9
Annual Total ...	1,483 4	1,532·7	1,316·0	— 49·3	+ 167·4

* Kindly furnished in MS. by Mr. Joseph Baxendale, F.R.Met.Soc., Borough Meteorologist.

amounting to 47 inches, while at Bidston the rainfall is only slightly over 28 inches.

The amount of cloud as estimated at repeated intervals during the day can be conveniently exhibited in tabular form in connection with the humidity derived from simultaneous readings of the dry and wet bulb thermometers:—

Month.	Mean Percentage of cloud.	Mean Difference of Dry and Wet Thermometers	Humidity Mean Percentage.	Mean Daily Range of Percentage.	Vapour in one cubic ft of air.
		°			grs.
January ...	72	1·83	83	13	2·3
February ...	71	2·07	79	12	2·4
March ...	70	2·69	82	11	2·5
April ...	63	3·28	78	12	2·8
May ...	62	4·17	71	17	3·2
June ...	64	4·20	70	18	3·9
July ...	67	4·29	72	20	4·2
August ...	66	3·88	72	22	4·4
September	67	3·47	73	19	4·3
October ...	71	2·62	77	17	3·4
November ...	71	2·04	82	12	2·8
December ...	72	1·92	81	10	2·5

The amount and distribution of precipitation are among the most important factors in climatology, and the mean value of the amount is one of the most difficult to obtain, such long periods of observation are necessary for accuracy. The measurement is especially uncertain, because the amount collected from gauges placed but a few yards apart will differ materially from day to day. Wind and difference of level are probably the principal causes of irregularity. At Bidston it has been the practice to read the amount of rain collected in a gauge on the ground, and in one at the top of the building, some 50 feet higher. The amount collected in the lower gauge is on the average one-sixth more than that in the higher level, but in single rainfalls at times of high wind the discrepancies are even greater. The obstruction presented by the building, particularly on the west front, the direction of the prevailing wind, obliges the air to rise, carrying the rain over the gauge without deposit. The same cause operates no doubt to a lesser extent near the ground, and the measured amounts are probably too small. The amount of rainfall given in the following table is derived entirely from the readings of the ground gauge. The automatic records of the upper gauge are used only to determine the time at which the rain fell. In the case of very light showers these times are not indicated with great accuracy, and the time of snowfall cannot be recorded at all. These records of time may be dismissed by saying that the precipitation is distributed fairly uniformly throughout the 24 hours, though there is some indication of maxima at 5 hours and again at 21 hours. The driest times of the day appear to be 14 hours and 24 hours. The average number of hours during which rain actually falls is under 50 per month, varying from 70 in the wettest to 30 in the driest months of the year. But when to the uncertainty in measurement is added the great variation in rainfall from month to month, and from year to year, monthly averages become very insecure. The annual rainfall will vary from 20·8 inches (1887) to 45·7 inches (1872), and longer intervals of time

would show greater irregularities; a range of such extent makes many years' observation necessary to obtain a correct value. In the table the total period of 56 years is divided into two equal portions, and the durations between the records of the several months are striking. In September, for example, the rainfall in the two periods differs by nearly an inch, and clearly 30 years' observations would be insufficient to give a trustworthy average. Fortunately, reliance on such matters is of little value, but the mean of the figures in the two columns, or the mean derived from the whole 56 years' period, will be materially altered by subsequent observations.

RECORDS OF MONTHLY RAINFALL.

Month.	Average Monthly Rainfall, 1866-1894	Average Monthly Rainfall, 1894-1922	No. of days when Rainfall exceeded 0·01 inch.	Maximum Monthly Rainfall, and Year.		Minimum Monthly Rainfall, and Year.	
	inches.	inches.		inch.		inch.	
January ...	2·14	2·19	23	4·61	1877	0·71	1889
February ...	1·69	1·72	17	3·60	1904	0·11	1891
March ...	1·63	2·14	16	4·91	1919	0·53	1893
April ...	1·59	1·73	14	3·97	1920	0·20	1912
May ...	1·94	1·93	15	4·72	1886	0·40	1876
June ...	2·03	2·07	14	4·71	1907	0·10	1921
July ...	2·97	2·38	13	7·51	1872	0·24	1868
August ...	2·91	3·18	19	6·21	1879	1·16	1871
September	3·17	2·30	13	6·58	1872	0·46	1910
October ...	3·59	3·06	20	7·37	1903	0·31	1922
November ...	2·80	2·12	21	5·05	1877	0·65	1920
December ...	2·63	2·88	18	6·14	1918	0·51	1905

The heaviest rainfall in 24 hours, amounting to 2·03 inches, occurred on June 25th, 1891, and the maximum in any one hour on August 10th, 1890, when 0·909 inches fell in 54 minutes.

Wind.

The direction and velocity of the wind influence the climate of Liverpool very materially, and the determination of these factors has been pursued through many years with instruments of various design. Some of the

apparatus has been used continuously for the 56 years under consideration, and though the results may be relatively comparable, yet in the light of recent investigations the absolute values may be questioned. The mean velocity derived directly from the instrumental records throughout the entire period slightly exceeds fifteen miles an hour, but on modern apparatus this figure would be reduced to twelve. The values for direction are more trustworthy than for velocity, and the table below shows the number of days in each month during which the wind was blowing from each

Month.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	N.
	days.	days.	days.	days.	days.	days.	days.	days.
January ...	1·8	3·6	8·4	3·8	5·8	5·2	1·4	1·0
February ...	1·8	3·5	6·1	3·0	5·4	5·6	1·8	1·1
March... ...	2·9	4·0	5·9	2·0	4·9	6·3	3·2	1·8
April	3·7	5·5	4·7	2·0	3·2	6·1	3·3	1·7
May	3·3	4·6	3·1	2·2	4·1	7·4	4·6	1·7
June	1·6	3·0	3·5	2·3	4·0	8·8	5·6	1·2
July	1·0	1·8	3·4	3·0	5·4	10·1	5·2	1·1
August ...	1·6	3·2	4·4	2·5	4·4	9·1	4·4	1·4
September ...	2·0	3·6	5·0	3·0	4·8	7·2	3·1	1·3
October ...	2·8	3·7	5·8	2·9	4·6	6·2	3·0	2·0
November ...	3·1	3·3	5·7	2·9	4·7	5·2	2·7	2·4
December ...	1·7	3·0	5·7	3·0	6·0	6·2	2·5	2·9

point of the compass in the average month. In the summer season, the direction of the wind is generally westerly, the south and south-east winds diminishing as the year advances. The higher velocities are connected with the movements of atmospheric depressions that travel from the Atlantic, and all the storms, defined by velocities exceeding 50 miles an hour, come from that direction. The average number of hours in the year which such velocities are recorded is 81, and the number of distinct storms is eight, mainly confined to the winter season. The maximum velocity recorded occurred on December 11th, 1883, when 92 miles were registered, but in the modern scale this number would be considerably reduced. Such velocities indicate a pressure of approximately 30 lbs. to the square foot, but the actual

record on the exposed pressure plate is far greater than this amount. There are several grounds for distrusting these high recorded pressures, which are operative over only a very small area, but the means of directly deriving the pressure exerted over a considerable surface are wanting.

THE TIDES OF THE IRISH SEA.

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In the following article we shall be concerned only with the average half daily tides. In these, high waters occur at intervals of half a lunar day, or about 12 hours 25 minutes of solar time, and low waters occur a quarter of a lunar day after high waters. At any one place, of course, high water occurs at all hours of the solar day, but if we use lunar time high water in the average tide will occur at the same hour in each lunar day. Lunar noon being the time of the moon's crossing of the meridian of Greenwich, we have, for example, 10h. 54m. lunar time as the time of high water at Liverpool, both "morning" and "evening." The heights of high water are of course intermediate between those of spring tides and neap tides at the same place. Similar remarks apply to the tidal currents; at any place these repeat themselves every half lunar day, always acquiring their greatest speed at the same lunar time, and the greatest speed being intermediate between those of spring tides and neap tides.

Along the coasts the times and ranges (i.e., the differences in level between high and low waters) are determinable from simple observation. For Liverpool we can state accurately that the time of high water is 10:54 and that the range is 19.95 feet, but for most other places we have to make inferences from the times and ranges at average spring and neap tides, since these alone have been recorded.

A complete knowledge of tidal elevations over the whole area of the sea would enable us to construct charts of co-tidal lines and of co-range lines. A co-tidal line is such that at every point on it high water occurs

at the same time, and a co-range line such that at every point on it the range of tide is the same.

But away from the shore the problem of observing tides is very difficult, and most observations have been restricted to currents. Much information on the tidal currents of the Irish Sea has been published by the Admiralty, based on observations dating from those of Admiral Beechy in 1848. The outstanding results are

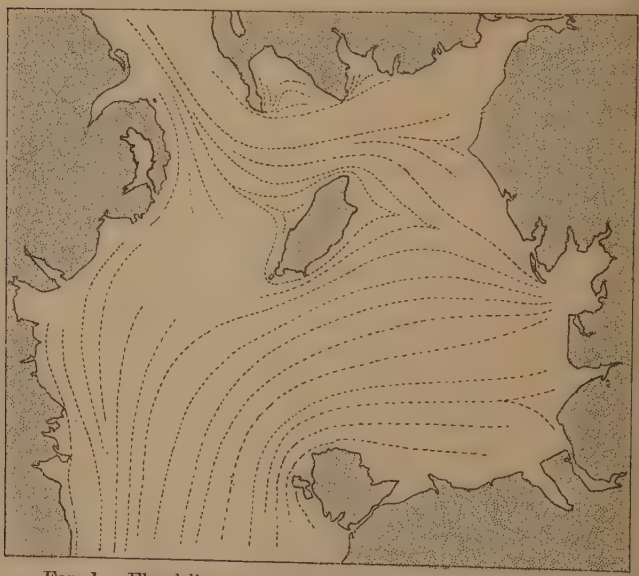

Fig. 1. Flood-lines for the Irish Sea. (Beechy, 1848.)

that in the Main Fairway the currents practically keep to the lines shown in Fig. 1, and that they all attain their greatest speed at about 8 o'clock in lunar time.

This knowledge of the tides of the Irish Sea may be considerably augmented by the application of the principles of Mechanics, as we shall now proceed to show.

The primary cause of the tides lies of course in the varying forces of gravitational attraction due to the moon and sun. But it is in the basins of the great oceans that these forces really generate the tides. As acting on the water of the Irish Sea they are practically negligible, the fact being that these tides are maintained by those of the Atlantic. If the Irish Sea were landlocked its tides would be almost imperceptible.

For precision we will consider the basin enclosed by a section running from Kingstown to Holyhead and one from Port Patrick to Donaghadee, which we shall call respectively sections S and N. The tides of this basin are determined by the distribution of current over the sections S and N. We know from observations that the currents, averaged across these sections, both run inwards with maximum speed at about 7:50 in lunar time. These currents will turn back and begin to run outwards three lunar hours later or at 10:50 in lunar time.

It is easily seen that when these currents are on the point of turning back there will be the maximum amount of water in the basin, and that when they reach their maximum speed either inwards or outwards there will be the mean amount of water in the basin. The speeds of the currents across the sections S and N and the areas of these vertical sections determine the excess of water in the basin at any time over the mean amount. And then the area of the surface of the sea determines the average surface elevation at this time above the mean level. When this average surface-elevation is at a maximum, viz., at 10:50, it is about 7 feet.

The currents follow the lines of Fig. 1, which we shall call the flood lines. If through a pair of near flood lines we draw a pair of vertical surfaces we shall have what we may call a flood tube; its cross-sections will be practically rectangular. Now the maximum inward rate of passage of volume of water along any tube continually decreases in the direction of flood on account of the abstraction of water required to form

the rising tide en route. If the sectional area of the tube remains constant along a portion of its length then the maximum speed of the current will diminish along this portion; if the sectional area increases then this diminution of speed will be augmented, but if the sectional area decreases then the diminution of speed will become less and the speed may even increase.

To the west of the Isle of Man the sectional area of the tubes is much increased owing to the increase in depth, so that the currents there are very small. Of course they must vanish altogether where the tubes from the sections S and N meet. Also, owing to the diminution of depth to the east of the Isle of Man the maximum speed of the currents there is as great as it is to the south of the Isle of Man. Again, in passing round a headland such as Ayre Point, Isle of Man, the horizontal breadth of the tubes is much decreased and on this account the speed of the currents is increased.

The currents build up the elevations and produce surface-gradients. These surface-gradiants determine accelerations which reduce the currents to rest and then turn them back.

To consider more particularly these surface-gradients and accelerations we will first suppose that the earth is non-rotating and that the water moves without friction. At the time of maximum flood, viz., 7:50, the surface of the sea would be flat and at its mean level, and there would be no accelerations. But at 10:50, the surface-gradients in the direction of the flood would be at a maximum and the backward accelerations at a maximum. High water would occur everywhere at this time.

The magnitudes of the surface-gradients could be calculated from those of the accelerations, which in turn could be calculated from those of the currents. At the maximum they would give an increase of level of about 4 feet along the longest flood lines. Combining this with the 7 feet average elevation at 10:50 we see that the maximum elevation will be about 5 feet near the sections S and N and about 9 feet near

Walney Island. Perpendicular to the flood lines there would be practically no accelerations, and therefore no surface-gradients. It follows that the co-range lines would be practically perpendicular to the flood lines.

But owing to the rotation of the earth there is also an acceleration to the left of the current, which is proportional to the speed of the current, and this reaches its maximum about 7:50. Unless there is an

Fig. 2. Co-range lines for the Irish Sea. (Ranges in feet.)

immediate turning of the current to the right out of and away from the flood line to produce a counter acceleration there must exist a second gradient rising to the right of the flood which would reach its maximum about 7:50. The former alternative would imply currents which changed direction from hour to hour, and there is little evidence for this in the Irish Sea. The latter alternative requires gradients of about three-

quarter of the magnitude of the primary gradients, and thus involves at 7:50 elevations of about $1\frac{1}{2}$ feet above the mean on the Welsh coast and depressions of about $1\frac{1}{2}$ feet below the mean on the Scottish coast.

The retarding effect of friction is greatest when the currents are at a maximum, and at this time requires a counterbalancing downward gradient along the flood lines, since the accelerations are necessarily zero. The level surface of 7:50 is thus again disturbed; it will be elevated near the sections S and N and depressed near the ends of the flood lines.

The changes of level produced by the earth's rotation and friction are small compared with the primary elevation, and as they reach their maxima about three hours before high water their effect on the range is very small. The co-range lines remain practically perpendicular to the flood lines. The effects on the times of high water are also small, but are very interesting. That of rotation is to make high water a little earlier than 10:50 on the Welsh coast and a little later than 10:50 on the Scottish coast. On the Irish coast northward from section S the time of high water will be a little later than 10:50, while southwest from section N it will be a little earlier than 10:50, the effect vanishing somewhere between. Friction makes high water a little earlier near the sections S and N and a little later near the ends of the flood lines. The two effects are in conjunction near Holyhead and Donaghadee and in opposition near Kingstown and Port Patrick. On the Irish coast northwards the times of high water reach a maximum. Rotation and friction are each instrumental in bringing into existence co-tidal lines; rotation alone would make these lines run in the general direction of the flood lines, though with a little separation as they advance; friction alone would make them practically perpendicular to the flood lines. The combined effect is to turn them to the right away from the flood lines, and this turning effect is predominant in the estuaries, where high water occurs progressively later in the direction of the flood.

The elevations and depression existing at 7:50 require currents to produce them and to carry away the water. On the Welsh coast these will be running out with maximum speed about 10:50, while at the same time they will be running in on the Irish coast past Kingstown. These currents will be small compared with those of flood, but it is noteworthy that there cannot be a complete absence of currents at 10:50. Also, the

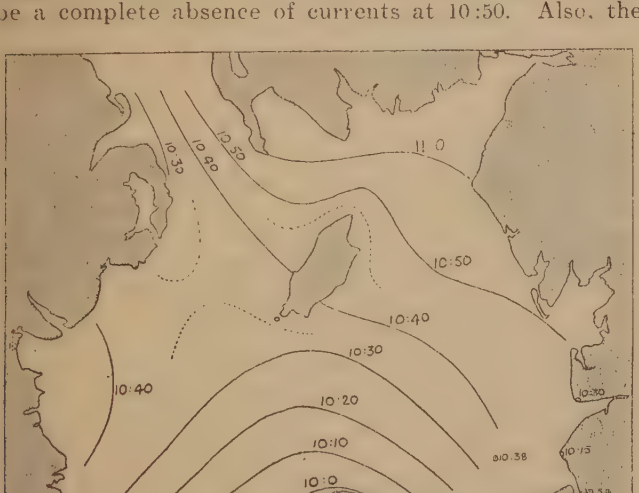

FIG. 3. Co-tidal lines for the Irish Sea. (Time in lunar hours and minutes.)

time of maximum current at any section of a flood tube will be the same as that of the mean volume of water in the tube in advance of this section. The effect of friction is therefore to make the currents later in the direction of the flood, and consequently the maximum currents occur less than three hours before the high water, except at the ends of the flood lines.

When the above principles are made precise by their translation into differential equations we are able to construct the charts shown in Figs. 2 and 3, though owing to the imperfection in the data some of the features of these charts are a little hypothetical.

A chart somewhat like that of Fig. 2 was given by Beechy, but no chart like that of Fig. 3 has been previously published.

THE MARINE BIOLOGY OF THE IRISH SEA.

Jas. Johnstone,
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(1) Historical Account.

Systematic investigation of the Irish Sea area was first organised in 1885. In that year a meeting was held at the (then) University College of Liverpool under the presidency of Professor Herdman, and representatives of the Scientific Societies and Museums of Liverpool, Manchester and Chester, as well as individual naturalists, attended and resolved to form a Committee of Organisation. Prior to that time there had, of course, been some investigation of the region, notably by Professor Edward Forbes and Mr. R. McAndrew, a local merchant. In 1885, however, a definite body, the Liverpool Marine Biology Committee, was instituted, and this continued in existence until the year 1919.

The names of these pioneers in local marine biological work may be mentioned here. They were Professor W. A. Herdman, Professor R. J. Harvey-Gibson, Professor Milnes Marshall, Mr. Isaac Roberts, Mr. Isaac C. Thompson, Mr. T. J. Moore, Mr. A. O. Walker, the Rev. H. H. Higgins, Mr. F. Archer and Mr. R. D. Darbishire. Later on the Committee also included Lord Henniker, Mr. P. M. C. Kermode, Lord Raglan, Mr. A. Leicester, Dr. W. E. Hoyle, Mr. W. J. Halls, Sir Charles Petrie, Professor B. Moore and Sir J. T. Brunner.

When it dissolved itself in 1919 the members were: Lord Raglan, Sir J. T. Brunner, Professor R. J.

Harvey-Gibson, Mr. W. J. Halls, Mr. P. M. C. Kermode, Professor B. Moore, Sir Charles Petrie, Mr. A. O. Walker, Mr. A. T. Watson and Professor W. A. Herdman.

During the 34 years of its existence it gathered together many other workers, both professional biologists and some geologists, as well as many amateur naturalists.

At first the object of the Committee was the systematic investigation of the fauna and flora of the area in the immediate vicinity of the estuaries of the Mersey and Dee, but very soon the region was enlarged. Dredging and trawling expeditions were arranged, and Hilbre Island, at the mouth of the estuary of the Dee, was chosen as a centre for collecting. Very soon, however, some definite seaside station had to be established, and so the Committee obtained, from the Mersey Docks and Harbour Board, the use of the old signal station at Puffin Island, in the entrance to Menai Straits. This was fitted out as a Biological Laboratory and was used almost continuously from 1887 to 1892.

Then, the Puffin Island Station proving to be rather inconvenient, the Committee removed to the Isle of Man. A site was obtained at Port Erin, and a small building, with tanks and laboratory fittings, was erected. This was opened in 1892 by Sir Spencer Walpole (who, after having been an Inspector of Fisheries for England and Wales, and, with Mr. Frank Buckland, a Commissioner of Fisheries in 1879, became Lieutenant-Governor of the Island). From the beginning the Port Erin Station was in charge of a resident curator. In 1897 Mr. H. C. Chadwick (at present a Research Zoologist on the staff of Liverpool University) was appointed to this post.

Again the Station became small and inconvenient for the expanding work, and so a new one was built on the opposite side of Port Erin Bay in 1902. This building included a small public aquarium, a fish hatchery (maintained by the Insular Government) and accommodation for about a dozen workers. About 1900, a new

policy was adopted by the Committee: there was a growing demand, not only for facilities for research but also for the instruction of senior students from the Universities. This was provided in the new Station of 1902, but in 1910 it was found necessary to enlarge the laboratory. An additional wing was, therefore, built with more tanks and room for about a dozen workers. This, then, is the accommodation that now exists, but in 1921 a chemical laboratory was also equipped.

Almost parallel with the development of the 'L.M.B.C.' organisation was that of the Lancashire Sea Fisheries Committee. This was instituted (by an Order under the Sea Fisheries Regulation Act of 1888) in 1889, but later on it took over the Cheshire area, and, later still, the seaboard of the Welsh counties down to Glamorgan. The Fisheries Committee was fortunate in having as its first Chairman the late Mr. John Fell, of Ulverston, and as its Superintendent the late Mr. Robert A. Dawson. Under these two gentlemen scientific investigation was begun and actively prosecuted. Two laboratories were established—one in the Zoological Department of the University of Liverpool and another at Roa Island (Piel) in the entrance to Barrow Channel. Professor Herdman was put in charge of the fishery investigations, and associated with him were Messrs. Andrew Scott and James Johnstone (at Piel and Liverpool respectively).

The scientific work of the Lancashire and Western Committee was carried on in circumstances of great difficulty. It is characteristic of English administrative policy that the local Fishery Committees were (and are still) entrusted by the Government with the regulation of the fishing industry in their areas, with the elaboration of by-laws and the prosecution of offenders without having any direct and expressed power to institute and provide for scientific enquiry. But, in spite of this, and by taking advantage of a provision in another Statute, they were able to carry on investigations. Extensive fishery statistical work, as well as faunistic research, was made

ever since 1892. In 1906 a powerful vessel of about 140 feet in length was built and equipped for marine research, and this was progressively developed. Oceanographic investigation was begun in 1907. Plankton research by the quantitative Hensen methods was also started then, and the first experiments made in British waters with the Petersen bottom-samplers were made in 1912. By arrangement with the Irish Fishery Authority a joint programme of hydrographic investigation was organised and followed for several years prior to 1914. In 1899 the Fishery Committee, in collaboration with the Lancashire Education Committee, organised a scheme of instruction for fishermen at the Piel Laboratory, and every year, from then till 1914, some 40 to 50 men put in a fortnight's course each at the Station. Latterly, Navigation and Seamanship, as well as Biology, were taught, and the Piel School became very successful in preparing fishermen for the Board of Trade examinations.

In 1919 the 'L.M.B.C.' was dissolved. In that year the new Department of Oceanography at the University of Liverpool was founded by Professor and Mrs. Herdman, and the Port Erin Station was transferred to the University. In 1921 Dr. James Johnstone succeeded Professor Herdman in the Chair of Oceanography and assumed the direction of the Port Erin Station and the scientific work of the Lancashire and Western Sea Fisheries Committee.

(2) Publications.

The work done at the Puffin Island Station is summarised in a series of six *Annual Reports of the Puffin Island Biological Station*, 1886 to 1891. This series is followed by another of 36 *Annual Reports of the Port Erin Biological Station*, 1892 to 1922 (the latest one). The detailed results of the systematic Biological work are contained in a series of five volumes, *The Fauna of Liverpool Bay*, 1886 to 1900. In 1899 a new series of publications, the *L.M.B.C. Memoirs*, was

started. There are now 25 of these reports, each being a monograph on a common marine animal or plant.

The results of the fishery investigations are contained in a series of publications issued by the Lancashire and Western Sea Fisheries Joint Committee. These are the 30 *Annual Reports of the Lancashire Sea Fisheries Laboratory,'* beginning with that for the year 1892; two *Lancashire Sea Fisheries Memoirs*, published in 1899 and 1902; 31 *Quarterly Scientific Reports*, beginning in 1906 and ending in 1915. In addition to these scientific papers there are the official *Proceedings* of the Committee and the *Superintendent's Quarterly Report* beginning in 1889.

(3) The Physical Area.

The Irish Sea is an 'Epeiric Sea' situated wholly on the continental shelf, and therefore a shallow water basin. It is bounded by the South Coast of Scotland; the Coasts of Cumberland, Lancashire and the Welsh Counties as far South as Anglesey; and the East Coast of Ireland between Counties Dublin and Antrim. On the western side, between Ireland and Isle of Man, is an elongated trough with depths of 50 to 90 fathoms. This is continuous with the North Channel (between Ireland and the South-west Coast of Scotland), where the depth increases to 149 fathoms, and with St. George's Channel (between Ireland and the coast of Wales), where the depth varies between 50 and 70 fathoms. East of Isle of Man and between here and the English Coast the depth is mostly less than 20 fathoms.

The two opposing coasts, those of Ireland and England and Wales, are rather different in character. That on the west presents a relatively unbroken outline. but on the east there are a series of great bays and estuaries — the Bristol Channel, Cardigan and Carnarvon Bays, Beaumaris and Liverpool Bays, the Estuaries of the Dee, Mersey and Ribble, Morecambe Bay, the Estuaries of the Duddon and Solway, Wigton and Glenluce Bays.

The southern entrance to the Irish Sea area, between the Tuskar and Smalls Lights, is much wider than the northern one, between Mull of Galloway and the Antrim coast, so that the tides are stronger in the south than in the north. On the west (off the Irish Coast) the tidal elevations are lower and the streams are less rapid than on the eastern side. The effect of the rotation of the earth is to deflect the tidal streams to the east over the greater part of our area—from the Bristol Channel as far north as a line between Ramsey Bay, in Isle of Man, and Morecambe Bay, on the English side. There has, therefore, been greater erosion of the coast on the eastern side, and this is represented by the great bays and estuaries with their great tracts of shallow water, extensive sand banks, high spring tides, and rapid tidal streams. More water enters the Irish Sea through the southern entrance than through the northern one, and so there is a slow resultant drift from south to north. This is such that the whole volume of water in the basin (about 3,000 cubic kilometers) passes out through the North Channel once a year.

The sea bottom presents comparatively little variety, being mostly covered by quartz sand. Here and there are extensive neritic deposits of worn molluscan shells and nullipore fragments, and in the deeper trough-like depressions there is some mud. Where there are tidal eddies, as in the south-east part of Morecambe Bay, there is some mud, and off the Coast of Cumberland mud also accumulates. The bottom of the larger bays is mostly clean quartz sand, but in the shallow channels in the estuaries the sand is mixed with a good deal of mud. In parts of the bays and estuaries, and in particular near the land, the bottom is often very soft, forming 'quicksands.' Where these are present there appears to be an upwelling of water from underneath.

The clean, hard sandy bottoms in moderate depths (5 to about 20 fathoms) are the richest fishing grounds. Trawling is, therefore, practised to a greater extent on

the shallow sea bottom between England and the Isle of Man, and in the great Welsh bays, than in the trough between the Island and Ireland, or in the deeper parts of St. George's Channel.

(4) The Results of Investigation.

The systematic investigation of the Irish Sea district, begun in 1885 by the Liverpool Marine Biology Committee, has, of course, been continued. In the *Handbook to Liverpool and the Neighbourhood*, published by the British Association at their meeting in 1896, about 2,090 species of marine animals were recorded. Full lists, both of the animals and plants, are given in Vol. V of the *Fauna of Liverpool Bay*, and further lists of 313 species found since 1896, are given in the *33rd Annual Report of the Marine Biological Station at Port Erin* (1919). Thus about 2,400 species of marine animals and about 100 species of marine plants are now known to inhabit the Irish Sea area. It is certain that very many more exist because the area that has been systematically investigated is, after all, only a small part of the whole region. Considerable additions to the lists will doubtless be made when the St. George's Channel area, that off shore from Cardigan and Carnarvon Bays, and the Solway Firth are thoroughly trawled and dredged. Hitherto the animals inhabiting the bottom deposits in the deeper parts of the western trough are not at all well-known because of the difficulty of adequately sampling this material. When it is investigated by the use of the Petersen bottom-sampler, for instance, many additional records will doubtless be made. So, also, further plankton research is sure to reveal a number of organisms hitherto unrecorded. The work already done in this direction has been restricted to the macro-plankton, and the investigation of the very small organisms that are able to pass through the meshes of the tow-nets so far employed is certain to be fruitful of results.

It is unnecessary to deal further here with the systematic biology of the Irish Sea region. The various publications mentioned above, with the *Handbook* published by the British Association at their meeting at Southport in 1903, Coward's *Vertebrate Fauna of Cheshire*, Forrest's *Vertebrate Fauna of North Wales*, and the publications of other local natural history associations, contain detailed statements as to the identity and distribution of the plant and animal organisms of the district. It is quite certain that further research will add largely to the lists of known species, but it is also certain that far less of the purely systematic investigation will fall to be done by the amateur workers of the future. Ordinary methods of collecting must have revealed most of the species that are accessible, and the additional methods necessitate considerable organisation and expense. Intensive investigation of the micro-plankton requires very special apparatus; a further description of parasitic forms is, perhaps, beyond the time and resources of naturalists who have not daily access to large libraries and complete laboratory equipment, and the investigation of the deeper water requires the use of a large vessel and very elaborate apparatus. It is not possible to neglect the further purely systematic faunistic and floristic research, for a knowledge of specific forms and their distribution is sure to be required whatever may be the direction of marine biological research in the future.

Some of the more general results of such investigations, carried on since the last Liverpool meeting of the British Association, may now briefly be noticed.

Physical Investigations. In 1906 the Lancashire and Western Sea Fisheries Committee began to make hydrographical observations, adopting the standardised apparatus and methods elaborated by the International Council for the Exploration of the Sea. That is, a number of 'stations' were selected and periodic 'hydrographic soundings' were made at these places.

Two lines of stations joined England and Wales to Isle of Man, and other two lines ran across the mouths of Cardigan and Carnarvon Bays. At each station the sea temperature was observed at the surface, the bottom, and at various depths; samples of the water from each station were taken for analysis, and plankton collections were made at the surface and at each station. The object of this procedure was to trace the slow drift of Atlantic water into and through St. George's Channel and the Irish Sea, this moving body of water being identified by its density, temperature, and plankton contents. Later on, arrangements were made with the Irish Fishery Authority for joint investigation, and the whole channel between Ireland and England and Wales became included in the scheme of investigation. The scheme in the Irish Sea east from Isle of Man was again extended in 1912. The last hydrographic cruise was made in September, 1914, after which the Committee's steamer and crew were taken over by the Admiralty to be employed, during the war, on the Dover Patrol. It was hoped to resume the investigations in 1920, when the steamer came back, but increasing financial stringency made this impossible.

The results of the observations made show, however, (1) a slow drift of water from the Atlantic into St. George's Channel and Irish Sea and out through the North Channel: (2) the gradual dilution of this oceanic water by the rainfall and the entrance of river water from the land so that the salinity (quantity of solid matter, in grams, in 1,000 grams of sea water) decreases from south to north; and (3) a variation from month to month in the volume of Atlantic water entering the Channel. The rate of inflow is least about October or November, and is greatest about May or June. Further, the month during which the inflow culminates varies from year to year. The main drift of water through the Irish Sea is through the Channel between the Isle of Man and England and Wales because of the deflecting effect of the earth's rotation.

The general resultant flow of water through the Irish Sea is, therefore, from south and west round Anglesey into the Irish Sea, east from Isle of Man, and then to north and west out through the North Channel. In spite of this general northerly drift, it is probable that there is a slow creep of shore materials to the south and west along the Lancashire coast.

Plankton Investigations. The examination of the drifting microscopic life of the sea—that is, the plankton—was a part of the general scheme of observations devised by the L.M.B.C. at its inception in 1885. In 1906, however, the methods were greatly extended and elaborated. In that year the Fishery Committee began the quantitative investigation of the plankton on the eastern side of the Irish Sea, using the vertical Hensen net. At the same time Prof. Herdman prepared a scheme for the intensive study of the plankton of Port Erin Bay and the adjacent sea area, also adopting quantitative methods. The Fishery Committee continued its series of samplings for several years, and the Port Erin work was carried on continuously from 1907 to 1921. All the samples collected were examined by Mr. Andrew Scott, of the Piel Fishery Laboratory. Altogether about 7,500 separate collections were made and, on the average, each of these contained about 30 species of organisms. These individual organisms have been identified, and the numbers of each species present in each sample have been estimated. The working up of this material is now complete, and the general results are being published by the Oceanography Department.

A few words may be said here about these general results. There is a definite series of change in the nature and abundance of the planktonic species, and this succession is nearly the same from year to year, because it depends on (1) the annual variation of sea temperature, (2) the varying intensity of sunlight, and (3) the nature of the organisms themselves. Taking the conditions at Port Erin, we find :—

The cold 'Winter' months, December to February: There is a general poverty in the plankton in general, and the numbers of individuals taken, per average haul of the net, are relatively few.

The 'Spring' months, March to May: There is a great outburst of vegetable life in the sea, and the plankton consists mostly of Diatoms. At the same time the fishes and many invertebrates spawn.

The 'Summer' months, July to September: The Diatoms diminish in number to the extent that they almost disappear in August. The animal plankton, principally the Copepods, the Peridinians, and the invertebrate larvae, become very abundant. Towards the end of this period there is usually a renewed reproduction of some of the Diatoms.

The 'Autumn' months, October to November: All planktonic species diminish in numbers.

There are, of course, individual exceptions to this general sequence. There is one conspicuous winter Diatom, *Biddulphia sinensis* (December), and some summer forms, *Rhizosolenia* (in June and July). Still the general striking succession is that stated. There may be notable differences from year to year in the absolute abundance of each species at the time of its maximum reproduction, and there are, of course, differences in the physical conditions—sea temperature, salinity, and intensity of sunlight. So far, however, a correlation between the variations in physical conditions and the varying abundance of the plankton from year to year is very difficult to establish.

General Physiological Research. First we may notice the results of the fishery research in so far as these have been directed towards elucidating the life-histories of the commoner species of edible fishes. A great mass of statistical biological data have been accumulated and discussed. Fishery trawling experiments have been made, and very many thousands of plaice, herrings, cod, soles, dabs and other fishes have been measured and weighed and their sexual condi-

tions, spawning, habits, etc., made out. At the same time several thousands of living plaice, flounders and soles have been marked and liberated, and, from the data obtained when these fish were re-caught, their migration paths and rates of growth have been deduced. All this work has general biological interest, though its original motive was the study of legislative restrictions on methods and seasons of fishing.

Metabolic Cycles. The annual physical changes in the sea are reflected in the series of physiological changes through which a marine animal passes in the course of the year. Some work of this kind has been done: thus the condition of the herrings from fortnight to fortnight throughout the season has been studied. When the Manx season begins the fish are 'lean,' the quantity of fat in the flesh amounting to about 1 or 2 per cent. This is in June; but as the season advances and the sea temperature rises the quantity of fat in the flesh increases until it attains to about 20 to 30 per cent. of the wet weight. This maximum occurs immediately before the fish spawns, and when the latter operation has been concluded the quantity of fat has fallen greatly. With the falling temperature it still further decreases towards its minimum value. A somewhat similar, though far less marked series of changes, occurs in the cod, but here the fat accumulates in the liver and not in the flesh. In the mussel similar changes, affecting both the quantity of fat and carbohydrate in the tissues, occur during the course of the year. Thus not only does the marine animal respond to seasonal changes by changed habits, but also by changes in the chemical composition of its tissues. Edible fish and other marine animals are therefore 'in season' or 'out of season' according to the time of year.

Photosynthetic Production. Very notable, and indeed fundamental, has been the work of the late Benjamin Moore and his colleagues at Port Erin Biological Station. Marine plants take the carbonic acid from its

solution in sea water and fix the carbon as sugar and starch: this is carbon-assimilation, or photosynthesis of carbohydrate. Sunlight is necessary in order that the energy required for the production of carbohydrate from carbonic acid and water may be obtained. Some of the details of this process were studied by Moore, Whitley and Webster, and the investigation was followed up by Baly and Heilbronn, of the Chemical Departments at Liverpool University. These investigations have shown what is the chemical nature of the process of photosynthesis, and they have followed this up by a study of the process of nitrogen-assimilation: it used to be thought that the ordinary green plant could not avail itself of the elementary nitrogen in solution in sea-water, but it is now apparent that proteid substance can be synthesised by the green plant, under the influence of sunlight, just as carbohydrate can be made.

Moore also studied the 'alkalinity' of the sea-water at Port Erin—this means, in practice, the changes in the quantity of free and combined carbonic acid. The latter is the source of all carbohydrate plant substance, and by tracing its changes the production of carbohydrate in the sea can be estimated. Moore showed that, in the sea round Port Erin, the quantity of carbohydrate synthesised by the Diatoms during the spring season amounts to at least *ten tons of moist plant substance per acre of sea per season.*

Fish Pathology. The diseased conditions of fish and shellfish due to what we ordinarily call 'disease,' or to parasitic lesions, are of practical importance in respect to the inspection of fish at the ports of landing or in the public markets by the Health Authorities. The scientific study of fish pathology has been a notable part of the work done by the scientists on the staff of the Fishery Committee, and was practically new investigation in this country. Malignant growths (sarcomata, etc.) have been described, curiously paralleling the conditions in the human animal. The

first case of tuberculosis (lupus) in a marine fish was described at Liverpool. A great number of parasites (crustacean, protozoan and helminth) have also been described.

(5) The Irish Sea Fisheries.

The continuous investigations made at Liverpool and Piel, under the Lancashire Sea Fishery Committee, have made the natural history side of the fishing industry fairly well known: one may safely say that the record of the Committee in this respect is unsurpassed. The results have been referred to above, and they are presented in the Reports of the Committee. Something may be said as to the fisheries in general.

The main fishing grounds in the Irish Sea are on the Eastern side, between Isle of Man and the Scottish coast, the English coast and that of Anglesey. Here there are great areas of shallow, sandy sea bottom, eminently suitable for trawling. South from Anglesey there are also fine trawling grounds in the great Welsh bays. West from the Isle of Man, in the deep water of the trough, and in the same depths in St. George's Channel, the trawling grounds are not nearly so productive.

The common fishes taken on the Eastern trawling grounds are plaice, dabs, skates and rays, gurnards, sole and flounders. These are indigenous species which are always relatively abundant. The deeper water off-shore and that to the west of Isle of Man is not nearly so productive to the trawlers. With respect to the *kinds* of fish caught, these grounds resemble the Firth of Clyde, but are not so good from the fisherman's point of view. The commonest fish taken there are whiting, grey gurnards and witches. The richest fishing grounds are the shallow water in and just off the great estuaries and bays.

There are migratory fishes that come on to the fishing grounds at particular seasons. To some extent the sole is such a seasonal fish, and so are cod and whiting.

Hake appear in the summer months to the south and west of Isle of Man. The mackerel, sea perch and grey mullet are also seasonal fishes, coming up into the Irish Sea from the south. Haddock are migrants from the north, but this fish is now very scarce: its last period of abundance was in the early nineties of last century.

The herring is very interesting. It has always come into the Channel between Isle of Man and Ireland (making round to the east of the Island as the season advances) in the months May to September. The fish are spawning ones. There has always been a Welsh herring fishery. These fish come up from the south, appearing in Cardigan Bay about October and disappearing (in Anglesey waters) about December or January. They also are spawning fish—thus there are both winter and summer herrings in the area. The herring fishery on the eastern side of the Irish Sea is far less regular. In the early nineties the fish were found along the Lancashire coast, and even in the Mersey estuary, and before that time there was a famous fishery in Parton Bay (in Cumberland). For the last 30 years or so, however, the herring has deserted the Lancashire and Cumberland in-shore waters, and it is very interesting to find that, in the winters of 1921-22 and 1922-23, they have come back again. Past records show similar invasions after long periods of absence. The causes are almost certainly connected with the varying influx of Atlantic water into the Irish Sea, but the treatment of the problem of herring migration in this area will require prolonged investigation.

Shellfish are important from the economic point of view. The mussel fisheries in Morecambe Bay and along the Lancashire and Welsh coasts are perhaps the most productive in the British Islands. So also with the cockle fisheries: one village in Lancashire (Cark-in-Cartmel) exported, in its best years, about 3,000 tons of these shellfish. Shrimps and 'pink shrimps' (*Pandalus annulicornis*) are also very abundant. The prawn, lobster and crab are not abundant, and the

fisheries for these crustacea are relatively poor ones. The Norwegian lobster (*Nephrops norvegicus*) is abundant in the Irish Sea, but the fishery is poor and undeveloped. There are periwinkle fisheries, but these also are unimportant. There are now no oyster fisheries (though 'deep sea' oysters are to be found in small quantities).

Very notable in the Irish Sea fisheries is the treatment of the mussel. Owing to exaggerated fear of the communication of enteric fever by sewage the fishery for mussels became a very poor one about the beginning of the century. Professor Klein, of Bartholomew's Hospital, made some famous experiments (for the Fishmongers' Company) in 1904-5. These laboratory experiments were repeated by the Lancashire Fishery Committee, in the open sea, in 1906-10, and the method was adopted in 1913 by the Conway Corporation. The method of cleansing sewage-polluted mussels was then adopted by the Ministry of Agriculture and Fisheries, who took over the Conway plant from the Corporation in 1915. Under their direction the process has become a conspicuously successful one on the commercial scale.

The Fishing Industry.—The general evolution of the fishing industry has been similar to that elsewhere in this country. Prior to about 1890 the main fisheries were smacking (from Hoylake and Fleetwood) and small-boat trawling: the whole district was the *locus* of a typically in-shore fishing industry. There had been flourishing herring fisheries between Ireland and Isle of Man, but this industry had greatly fallen away. About the beginning of the 'nineties steam trawling came in, and Fleetwood rapidly rose to importance. In 1914 there were from 200 to 300 steam trawlers using that port, which by then had become one of the finest organised fishing ports of the United Kingdom. During the period 1890-1923 the old-fashioned smack-trawling industry steadily deteriorated. So has, on the whole, the in-shore fisheries by small boats and the shell-fisheries are not now so important as they were.

The steam-trawling ports are Fleetwood, Liverpool, Dublin, Whitehaven and Douglas, but only Fleetwood is now of any importance. Subsidiary industries have developed at Fleetwood—ice-making, fish-preserving, oils and manures—and there is a good fishery and navigation school. The inshore fishery by small boats is best developed at Morecambe and in the fishing villages near Southport (Banks and Marshside). The Fisheries Organisation Society have established Fishermen's Co-operative Associations at Fleetwood, Morecambe and Conway, but the movement shows no signs of expanding, and is, indeed, alien to the general trend of the industry, which is towards centralisation and capitalisation.

The fishery industry in Isle of Man is not a progressive one. Here the popularity of the island as a tourist resort is against fishery development. The Solway fisheries are all small boat and longshore ones; with the exception of Annan there is no fishing port of any importance.